MACHINERY.

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SHEET STEEL IN ENGINE CONSTRUCTION.*

A. K. MANSFIELD.

TASTE in machine design cannot be governed by fixed laws. The term "taste" implies individual preference, which must obviously be eliminated from the selection of outlines or finish of a design, if laws are found to exist governing these matters.

One of the most conspicuous features of a modern engine, especially a horizontal engine, is the style of cover used on the cylinder or cylinders. Beyond the fact that the cover contains some plastic or powdered material to reduce radiation from the cylinder, its function is ornamental rather than useful. It cannot be denied that the eye is better pleased with that which the brain recognizes as harmonious and logical than with the reverse. With these few preliminary suggestions let us consider the different kinds of "cylinder jackets."

In early engines ornamental wood finish was applied to cylinders, and even at the present time is preferred by some few users of engines. When this kind of finish is used, polished brass bands are usually applied at the ends. I believe that large surfaces of brass on massive iron work, merely for finish, are not thought to be ornamental by most constructing engineers at the present time. Finished wood lagging is not durable and is unnecessarily expensive. Moreover, I find it hard to understand the logic of applying cabinet work in such a place. Why not rather put the cabinet work in a handsome desk or other article of furniture for the engineer, and in the interest of harmonious design strive to give the engine a massive and durable appearance in all its parts.

During a long period paneled staves of cast iron, with raised parts polished, have been used for cylinder lagging by most American engine builders. It has seemed to me that this might possibly be the last survival in engine work of architectural ornament such as is used in wood construction. This kind of ornament originated in the fact, often before referred to, that early designs for parts of machinery came from early pattern-makers who had been house carpenters or cabinet-makers, and in the want of knowledge of more suitable style, applied the ornate shapes, which, after centuries of use, had been found suitable and tasteful in wood construction. Whether the argument be conclusive or not, it led the Buckeye Engine Co., a few years ago, to apply to a few engines a cylinder covering less ornate than the paneled cast iron. This is illustrated in Fig. 1, which shows two cylinders of a compound engine. The jacket is made from heavy, rolled steel-plate. The bands at ends of cylinders are made from steel-plate about ¼ inch thick and are highly polished. The result is, this style of finish has met with so much favor that it has been adopted by this company for all engines. There is nothing really new about it, yet to abandon the conventional paneled finish after years of use on thousands of engines is a somewhat radical move. It need hardly be pointed out that the total weight of a jacket made in this way is much less than that of a cast jacket, while its durability is greater; moreover, with suitable special tools for its production, it may be made with less labor.

It has become a requirement of modern engine construction that suitable means shall be provided for catching oil after use, both in the interest of neatness and for economy. In visiting different power plants, one sees a great variety of means for this purpose—pans, hoods, etc., made of galvanized iron, tin or brass, in all possible shapes and conditions. The Buckeye Engine Company has recently adopted a crank-cover made of rolled steel, of such weight and so shaped that it is strong and of neat design. This may be thought a trifling detail, but it is becoming necessary to make such parts fundamental to the design of an engine, especially in high speed work, where centrifugal force may carry oil a good distance from its useful point.

Fig. 2 is a section of the guard referred to, showing the shape into which we roll the steel, by means of a special machine designed for the purpose and illustrated in Fig. 3.

Fig. 4 will serve to give an idea of the strength or resistance to change of shape of the guard, and Fig. 5 shows several of the finished guards.

In rolling steel into such shape as this it is necessary to roll from a piece, say half an inch or more wider at each edge than is enough to form the finished shield. This is to take "the crimp" in the waste edge which would otherwise mar the shield. This edge must afterwards be removed, which we do with circular shears, shown in Fig. 3 on the end of the rolls. This work is done very quickly and accurately, owing to guide rolls which form a part of the shears. The slots in the shields for the connecting-rod to pass through are sawed with a small circular saw. To one unaccustomed to this process it is a matter of some astonishment to see how rapidly and accurately thin steel may be sawed with the so-called "cold saw."

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PRACTICAL HINTS ON MECHANICAL DRAFTSMANSHIP.

THOMAS P. PEMBERTON.

The following hints are specially designed to meet the wants of those who are actively engaged in the duties of a drafting office, as well as the machinists who take an interest in designing, calculating and drawing machinery. They are the result of a

* See pp. 104 and 105 for illustrations.

long actual experience and close observation. It is therefore hoped they will be found useful.

The draftsman and the machinist meet constantly with a great deal that is worthy of note and remembrance. But unless some means are used for jotting down suggestions of modification and improvement; unless there are facilities for sketching new devices, mechanical movements and meritorious designs, the new ideas, forms and details are apt to be forgotten, become lost for future reference and may be for practical application in other directions.

There are two books that are always useful, and if kept neatly and carefully, invariably prove very valuable; these are the sketch book and the manuscript rule-book; the former for entering sketches and the latter entering data, rules and calculations. They should be the constant companions of every draftsman and machinist, and as the writer had a very well filled sketch and rule-book stolen from him, the suggestion that such books should be jealously guarded and preserved, may appear natural and not out of place. The man who steals a brother workman's sketch and note-book is—well, somebody else finish that sentence.

The use of a sketch-book involves a familiarity with the elementary principles of practical geometry and mechanical drawing, although free-hand drawing is chiefly employed in a book of this character. Sketches are mechanical drawings made on the same principles as finished construction or "working drawings" without the use of drawing instruments, a pen or pencil and an eraser being the only things needed.

A machinist should have two sketch-books—one to be used in the shop and one to be kept and preserved at home. The former may take the form of a pocket memorandum-book of moderate size, and the latter may be about 11 inches long by 9 inches wide, having its pages ruled with blue lines and a single vertical red line, but without dollar and cent lines. Such books are to be had from any stationer and are inexpensive. The paper should be of good, smooth quality, in a strong binding. The rough pencil sketches made during leisure hours in the small memorandum-book may be duplicated with improved execution in the home volume, and with such remarks and addenda as may seem necessary for explanation and completeness. The draftsman has always one or more of these strong sketch-books selected to suit his own special work and requirements. The very best and most useful sketch-books are those that are ruled for the purpose with vertical and horizontal colored lines spaced off in square inches, half, quarters and in eighths and tenths of an inch. Books of this description greatly facilitate the operation of sketching; the sketching should be done with liquid India ink.

A No. 3 or HHH pencil is about the proper grade for a sketching pencil; the lead may be a little softer or harder as may suit the sketcher. The point should be round and fine.

Too much attention cannot be given to *free-hand drawing*. It is the foundation of all good drawing of every kind; without its aid expert mechanical draftsmanship cannot be attained; by its means the eye may be trained to see correctly, and the hand to follow readily the dictates of the eye. It is a most valuable accomplishment, but expertness in it can only be reached by commencing to sketch simple objects on correct principles. There are students who have got so accustomed to drawing with T square, triangles, "straight edges" and drawing instruments that sketching in free hand, is positively irksome to them, and a slow operation. They began at the wrong end. After getting familiar with lines, angles and geometrical figures up to conic sections and acquainted with the rules of mensuration, they should have commenced to sketch shafts, bolts, nuts, screws, wheels, pulleys, engine and tool frames, etc. To every student I would say, go to sketching at once, sketch on every opportunity that comes to you; sketch simple objects at first and step up higher and higher to a complicated combination.

In sketching as well as in making a finished construction drawing, never forget that there are but two kinds of surfaces in nature and on all material objects, namely, plane and curved; that the edges of plane surfaces are lines and that round and curved surfaces are indicated by lines. Therefore, in sketching objects, every line you put down *means something*, for a line is the edge of a surface, or signifies the termination of that surface as it would appear if placed directly opposite your eyes. In the most complicated drawing you can only find straight and curved lines. There may be diagrams, center lines, radius lines, projection lines, dimension lines, but they all mean something. In representing, therefore, all kinds of machinery, the edges of surfaces are indicated by straight and curved lines.

With sketch-book, a lead pencil of medium hardness, a stylographic or common Esterbrook "Falcon No. 048" pen, outside and inside calipers, a steel square, a four-jointed two-foot rule, and a wooden measuring stick of suitable length—a draftsman or a machinist is prepared to sketch any and everything that has length, breadth and thickness in the constructive arts.

Sketching need not be limited to shop practice. Look about, and there are an infinite number of objects for studies—furniture, hardware, stoves, carriages, buildings, etc., etc. These can all be outlined in the sketch-book by pen or pencil. Pay especial attention to accurate outline. Don't endeavor to be artistic before you are mechanical. In your first practice you have little to do with shading, shadows, or striving after effects. Sketching is not as easy as you may imagine. Some persons have a talent for sketching quickly and in proportion. Learn to be accurate before you are quick or rapid; if you can get to be both accurate and rapid, so much more in your favor. About the worst thing is to be slow and inaccurate.

Another thing. You have, at any rate in commencing to practice sketching, nothing to do with perspective. Workmen and any other parties can frequently get a good general idea of a building or machine from a drawing in perspective, but men cannot measure or make patterns, as a general thing, from perspective drawings. Therefore, when sketching, draw just as the object looks when directly opposite, squarely before you. You are not supposed to look sideways, or at any convenient angle, but in the direction of straight, horizontal and vertical lines from the eye. Hence we get names of views technically and familiarly known as front elevation, side elevation, end elevation, back elevation, plan, general plan, longitudinal section, transverse section, etc.

Whether the aim is to become a professional draftsman in an engineer's or architect's office, or to become proficient as an amateur in free-hand and geometrical drawing, the art of sketching and measuring should receive close and constant attention as a most valuable accomplishment. By daily practice the student will be educating both hand and eye, and he will find it a fascinating, useful and pleasant employment. Besides, he will gather a stock of knowledge and information that will surprise him in its accumulation and its retention in the memory.

The rule-book should be of the same size as the home sketch-book (11 by 9 inches), ruled with blue lines and one vertical red line giving a convenient space for marginal headings. I have found it to be a convenient plan to divide the rule-book into departments or sections and indexing, so as to find a rule becomes an easy matter. For illustration: A book may be divided into the following sections:

BOILERS. Page 4.
- No. 1. Strength of boiler plate.
- No. 2. How to calculate bursting strength of cylinders.
- No. 3. Boiler power.
- No. 4. How to calculate heating surface.
- No. 5. Usual proportions for double-riveted seams, etc.

ENGINES AND STEAM. Page 20.
- No. 1. What is the relative quantity of heat required to convert a given weight of water into steam of different pressures.
- No. 2. How to read indicator cards.
- No. 3. Outside lap. Inside lap. Compression. Lead.
- No. 4. How to calculate H. P., etc.

GEAR WHEELS AND PULLEYS. Page 40.
- No. 1. Diametral pitch.
- No. 2. Proportions for teeth.
- No. 3. Calculations. Speed. Strength.
- No. 4. Strength of belts.
- No. 5. Rule for crowning of pulleys, etc.

MECHANICS. Page 100.
- No. 1. Calculations of levers. Mechanical powers.
- No. 2. Calculations of areas and contents.
- No. 3. Calculation of safety-valves.
- No. 4. How to calculate cutting of screws in lathes.
- No. 5. Definitions of mechanical terms, force, work, etc.

Additional sections may be Hydrodynamics, Hydraulics, Chemistry. Strength of Materials, etc.

Of course, the nature of the trade will govern the compilation of the rule book. An engineer's, a machinist's, a pattern-maker's.

a sheet-iron worker's rule-books will contain that which is thoroughly practical and useful in his specific employment.

To sum up. Every mechanic should keep his own sketch-book and manuscript rule-book, and I have given some hints about what to do and how to do it in this method of accumulating useful data and memoranda.

* * *

MODERN METHODS IN A BELGIAN SHOP.

THE WORKS OF H. BOLLINCKX.

ARTHUR BOLLINCKX.

In our engines we have adopted cylindrical or spherical forms only, that is to say that we never make use of a conically shaped piece in our construction.

Cylindrically shaped pieces are very easily measured and turned, and it is the same with spherical shapes, which are turned on a special lathe.

We have a measuring machine from M. M. Barriquand & Marre, of Paris, allowing to measure one-thousandth of a millimeter, and composed of a cast iron frame with two puppets, one of which holds the screw. This screw carries the dividing disc by friction so as to allow it to slide when the screw touches the piece being measured, and in this way one operator measures with the same accurateness as another. The machine is supplied with standard bars. It is by means of this machine that we make all our calipers, which are the same as those used in your country.

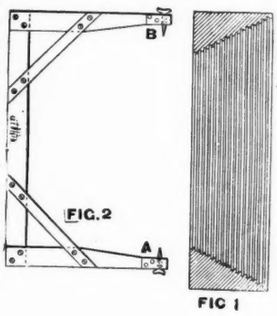


FIG. 2

FIG. 1

For our cylinders and heavy pieces up to 1.50 meters diameter we have stout pieces fixed on the walls, having all the grooves shown in figure 1. The above pieces are used as standard bars to test the calipers for boring and turning, the fitting in parts of our cylinders, pistons, covers, beds, etc., etc.

To measure such large diameters we make use of wooden compasses, having one point at A (Fig. 2) and a screw at B, allowing to measure easily one hundredth of a millimeter.

When in iron these calipers got out of shape when measuring, on account of the heat of the hands of the men. Made of wood they satisfy us in every way, and this is not a trifle when you observe that the two parts of our cylinders are fitting in each other without joints, and it is the cylindrical parts only that makes a joint.

For most of our work we measure by means of the compass, as per design A; one of the legs is split and tightened by means of a cam B. When the compass is at the desired opening at C, a screw allows to measure at $\frac{1}{100}$ of a millimeter. The man has near him a round gage giving the diameter to turn. he measures his gage by means of this compass, turns the screw C until he feels that the compass does not any longer pass freely, he then unscrews $\frac{1}{50}$ of a millimeter, and his compass will pass without contact. He therefore measures with a greater exactness than $\frac{1}{50}$ of a millimeter. When the piece is finished he passes the ring of his round gage in order to verify once more.

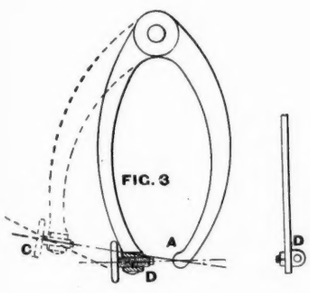


FIG. 3

We give the preference to the method shown in Fig. 3 in place of the gages which you are using on a large scale, I think, and which I have also been using. We will now go over to our mode of working.

All pieces under the size of 90 millimeters diameter are bored out on vertical machines, with "shucking" head, with four tools, two boring out, one drilling and one milling reamer.

We took a patent for this reamer in our country, and the reamer is composed of a steel core with cylindrical grooves in which we shrink in, by means of a hydraulic press, the blades which have first been tempered. These blades are conical to take up wear. They are employed in our tool shop, where they are sharpened and kept to gage. (See Fig. 4 and 5.) We employ the same system for roughing reamers for cast iron pieces. We then put the pieces on mandrel by means of the hydraulic press.

The mandrels are tempered and ground and have the $\frac{1}{20}$-millimeter taper; the bore is tested, for either the piece would not hold on the mandrel or would break if the hole is too small.

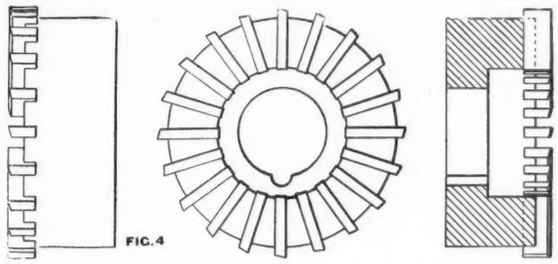


FIG. 4

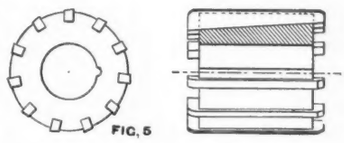
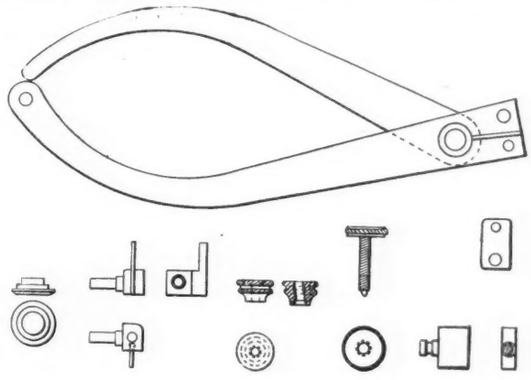


FIG. 5

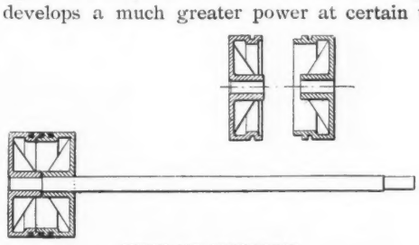
Having been turned in the lathe, nearly all the pieces go to the grinding machines, bought from Messrs. Landis Bros., Waynesboro, Pa. The pieces that have been planed are ground upon Messrs. Brown & Sharpe's flat surface grinding machine, admitting pieces 890 millimeters wide, 815 millimeters deep and 2 meters 500 millimeters stroke.

Our shafts are also ground (we use Norton wheels), by means of a wheel fixed on the carriage of the lathe and driven by a drum attached to the wall of the shop. The drum is 5 meters in length.

That is the general way of working in our shops. Here are some of the peculiarities. Our works consist of shops which, except the foundry, are halls of 8 meters width, with ceiling, and having a window-glass band or strip the whole length of the halls and 2.5 meters wide. The works are warmed by means of winglet tubes receiving steam direct from boilers, with return of the condensed water. Ventilating fans driven by power are at the end of the buildings to establish a strong current of air. They are lighted with arc lamps, and our overhead traveling cranes, eight in number, our pattern-making shop and our foundry, with seven machine tools, are all driven by motors.


DETAILS OF CALIPERS USED.

Owing to the regularity of our engine and the wide driving belts we use for the dynamo, the transmission for power and light are both performed with one 50 H. P. dynamo. The latter develops a much greater power at certain times, for the electric light only takes 150 amperes, and when all the traveling cranes work together, the dynamo supplies 450 amperes.


PISTON AND PISTON-HEAD.

Most of our machine tools were bought from American toolmakers, and among others we consider Flather's turning lathes superior to the lathes made in England. All the pieces of our engines are pressed in hydraul-

ically, and this even for pins of only 8 millimeters diameter. The holes we have to bore in certain pieces to get rid of the sand that remains in the cores, are stopped up by means of cylindrical iron plugs, usually of 50 millimeters diameter, and forced in by the press, and they never get loose notwithstanding the pressures of 10 atmospheres. Besides, these plugs are perfectly tight, a result not obtained with threaded plugs.

Our pistons are made in two pieces, pressed on the rod, consequently there is no bolt, no hole and no piece whatever to become loose. The piston rings are simply fitted into the piston grooves, without springs, and after ten years' work night and day, they have been found perfectly tight, required no expenses for maintenance and the cylinders had no appreciable wear.

We build our fly-wheels without keys or wedges, and we have been doing this for the past eleven years without a single failure.

All our lathes are running at a speed of 9 to 10 meters and all our pieces are annealed in a Brown & Sharpe furnace.

* * *

DIFFERENT METHODS OF PAYING LABOR.

A very interesting paper, dealing with the paying of workmen, was presented by Mr. Fred W. Taylor at the Detroit meeting of the A. S. M. E., in which is described a system which he introduced and which has worked very successfully in the works of the Midvale Steel Company, of Philadelphia.

The main fault with the piece-work system is that men dare not earn over a certain rate of wages, as they know that the rate will be reduced and more labor be required to earn the same amount as before. This is unsatisfactory in many ways, as it not only antagonizes the interests of the employes and his men, but encourages a slow rate of work and restricts the output of the plant, yet men can hardly be blamed for not doing their best in view of the reduction that will inevitably follow.

The premium plan of Mr. F. A. Halsey is being adopted in many places and has many advantages over the old piece-work method, as, after setting a time allowance on a piece of work, the saving that is made by the workman is divided between him and his employer. This principle is quite extensively used on railroads with regards to coal consumption, the Pennsylvania R. R. being one of the pioneers, and it works very satisfactorily to all concerned.

Mr. Taylor's plan is to fix a differential rate per piece as the output is increased, giving an incentive for fast work instead of punishing it by a reduction. As an example he cites a piece of work where ten pieces was the maximum output of the average workman, and the prices were fixed so that if ten were turned out per day the rate was 35 cents each; if less than ten, only 25 cents per piece was paid. Thus, if a man makes ten pieces he receives $3.50, but if he makes but nine he only receives $2.25. While this is a great inducement for high speed, it seems to the writer that there is too much difference between these rates for a difference of only one piece, making the extra piece equivalent to $1.25.* There are many details covered by Mr. Taylor with regards to fixing the rates which are valuable to any one interested in shop management, and he is to be commended for careful and conscientious work in this direction and for making an improvement in the existing methods, which we trust will be carefully considered by many. But while this may be welcomed as a step in the right direction, there remains the great factor of the shop manager's personal character, and as with other systems, there is a likelihood of reduction in rates when the men are earning too much, "too much" being usually regulated by what others can be hired for, neglecting many times the increased production from the same plant.

There is too much ignorance displayed in this respect by those who can only see dollars and cents paid to labor, without regard to increased production. Too many overlook the fact that, as the piece worker increases his wages by hard work, he is also increasing the shops profit, and instead of being satisfied with a portion of the gain, the shop manager (forced perhaps by an unpleasantly urgent call for increased dividends) wants it all and cuts prices, until it is little wonder that many dislike piece-work and will not work to the best advantage under it. When a man feels that he is receiving a fair portion of what he produces he is a far more profitable employee than, when (receiving less than he really earns) he is discontented and aggrieved. No matter what "ism" it may be called, any step toward securing to each the full product of their labor is in the direction of true economy as well as of honesty and justice.

* * *

* In other words, the workman fails to receive a proportionate price per piece as he increases the shop's production until he passes the limit set, in this case ten pieces. This is not strictly just, as the workman should receive an increased rate per piece as he increases the shop production, instead of not receiving any benefit until he passes the limit, even though he be delayed by accident or sickness from finishing that last piece. To be thoroughly just, the price per piece must advance (although not in a direct ratio perhaps) as the rate of work increases.

CONDENSERS.

WM. O. WEBBER.

The value of a condensing apparatus to any engine depends largely on the temperature of the injection water, the steam pressure and point of cut-off of the engine, as well as upon the type of engine itself.

The amount of water required to thoroughly condense the steam from an engine is dependent on two conditions: the total heat and weight of the steam and the temperature of the injection water.

Roughly, with 26 inches of vacuum and injection water not above 70°, from 20 to 30 times the water fed into the boilers will be required in the condensing apparatus to thoroughly do its work. If the temperature of the injection water is lower, much less, and if higher, much more water is required—viz, at 80° 35 times and at 90° 52 times the feed water.

To estimate the quantity of water required for condensing, the following formulas from the Condenser Catalogue of the Henry R. Worthington Co. is very valuable:

Let I = temperature of injection water.
Let D = temperature of discharge water.
Let S = total heat of steam at pressure

at which it leaves engine, averaging about 1,150°—for greater accuracy a steam table must be consulted—but as the exhaust usually runs from say 10 to 30 pounds the following short table will suffice:

Terminal Pressure, Pounds Per Sq. In.	Temperature of Steam.	Terminal Pressure, Pounds Per Sq. In.	Temperature of Steam.
10	1140.9	23	1153.7
11	1142.3	24	1154.4
12	1143.6	25	1155.1
13	1144.7	26	1155.8
14	1145.8	27	1156.5
15	1146.9	28	1157.1
16	1147.9	29	1157.7
17	1148.9	30	1158.3
18	1149.9	35	1161.0
19	1150.7	40	1163.4
20	1151.5	45	1165.6
21	1152.3	50	1167.6
22	1153.0		

Thus $\frac{S-D}{D-I}$ = required per pound of water fed to boilers.

Example, I = 70° F. D = 110° F. with 26 inches vacuum.
S = 1150

$$\text{Thus } \frac{1150-110}{110-70}=26$$

and you will require 26 times as much water for condensing purposes as you are using in your boiler and engine.

The advantages gained by using a condenser are an increase in the horse power of your engine and also a greater economy in the use of fuel per horse power developed.

The gain in horse power with 90 pounds boiler pressure would be about as follows.

Point of Cut-off.	Per Cent. gained by Vacuum.	Point of Cut-off.	Per Cent. gained by Vacuum.
$\frac{1}{5}$	11%	$\frac{1}{8}$	16%
$\frac{1}{6}$	12%	$\frac{1}{10}$	17%
$\frac{1}{7}$	13%	$\frac{1}{12}$	about 20%
$\frac{1}{8}$	14.7%		

at 70 pounds boiler pressure it would be:

Point of Cut-off.	Per Cent. gained by Vacuum.	Point of Cut-off.	Per Cent. gained by Vacuum.
$\frac{1}{3}$	16.5%	$\frac{1}{6}$	27.5%
$\frac{1}{5}$	20.%	$\frac{1}{8}$	30.%
$\frac{1}{4}$	24.%		

The per cent. gain in fuel would be about double the difference of the per cent. of power gained by vacuum, *i. e.*, with 70 pounds boiler pressure the difference by using condenser would be to reduce the cut-off from $\frac{1}{3}$ to $\frac{1}{4}$; the difference in power gained at these two points = 4 per cent. × 2 = 8 per cent. gain in fuel saved.

Exhaust steam from an engine enters a vacuum with a velocity of 1,900 feet per second, and water under atmospheric pressure at a velocity of 47 feet per second. It is, therefore, very necessary that a vacuum pump be very carefully proportioned to conserve the energy of the steam and not lose the benefit of its velocity. A duplex pump is, of course, the only type to do this work, and there are only one or two makers who fully understand the proportions necessary to a successfully working vacuum pump. There are

other types of condensers, such as the injector type, to be used where there is a sufficient natural head of water and room to construct an inverted siphon and the surface condenser with circulating pump attached. The trouble with the first is that it is hard to start, is liable to "let go" at any time and, if any of the check valves fail, liable to flood your engine.

This failing is also true in many cases with the surface condenser unless it is placed below the level of your engine cylinders. even then, if not very well constructed, it is liable to give trouble by leaky tubes. All surface condensers should be so constructed as to allow for the churn and expansion between the tubes and shell of condenser. Among other devices for condensing purposes one company has perfected a system of condensing by which a large supply of injection water is not necessary, it consists in pumping up the injection water and contained steam after leaving the exhaust to the top of a sheet iron tower, letting it fall in the form of spray and blowing a current of cold air up through this spray by means of a fan situated at the hollow of the tower, thereby cooling the water coming down so that it can be used over and over again, and curiously enough, enough extra water is supplied by the steam and atmosphere to more than make up any loss by evaporation, so that the small supply tank at the bottom of the tower is continually overflowing.

Parties desiring to change their engines from high pressure to condensing, would do well to consult a steam engineering expert and be guided by his advice as to the best methods to be employed.

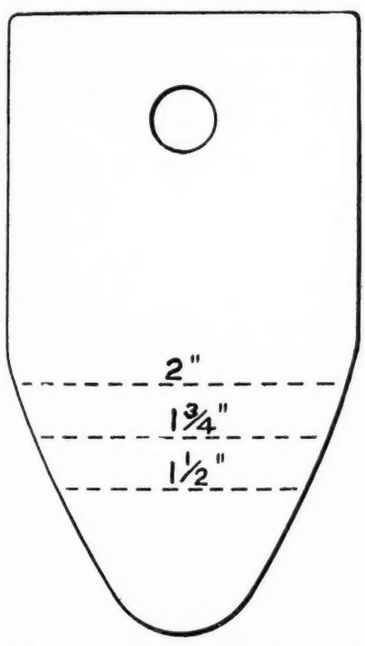
* * *

ROPE DRIVING AND GEARS.

SAMUEL WEBBER.

My old friend, Mr. John H. Cooper, rather "puts me in a hole" by quoting my account of the failure of a "rope drive," without giving the context which explained it, and which was, the turn of the rope, at nearly 7,000 feet a minute over an 18-inch or 2-foot idler pulley. I was protesting against too small diameters of pulleys for rope driving.

Here let me say that I advocate a much larger ratio of diameter of pulley to rope than Mr. Cooper suggests, viz.: for cotton rope, 40 to 1, from the best English authorities; for Manilla rope, 60 to 1, from the Dodge Mfg. Co., and for wire rope, 100 to 1, from the Trenton Iron Co



Mr. Cooper also makes me recommend an angle of 60° for the groove, but I only said that it was *theoretically* the best angle, but *practically* I preferred an English groove of about 53°.

The article as printed reads as if Mr. Cooper recommended the English groove, of which I enclose you a tracing from the template.

I quite agree with Mr. Cooper, in the truth of the old saw, that "There's nothing like leather," for many purposes, particularly for a heavy drive at moderate distances, where the shafts are parallel, but where the shafts are not parallel the rope system accommodates itself to the angle much better than a flat leather belt, and for a very long drive the saving in weight is an advantage; but I am not yet convinced of its ultimate economy, for although it costs less in the first installment, ropes wear out much faster and require renewal much oftener than leather. Good leather belts have been known to last in good working order for thirty or forty years.

I quite agree with Mr, Cooper, however, in preferring the "Dodge system," of a single rope, with but one splice, and a tension pulley, or the "multi-wrap" system, to the English plan of many separate ropes, each spliced, which throws the whole strain at first on the ropes which happen to be spliced the tightest.

I have read with great interest Mr. Klindworth's article on "Gear Teeth," in October number of your paper, and quite agree with him in many points; but as I am one of those who have advised shorter gear teeth, I must say that his illustration, Fig. 1, carries it to an extreme, far beyond anything I should advise. As near as I can measure his drawing, I make the total length of tooth shown there to be $\frac{3}{16}$ of an inch, while the pitch is $\frac{9}{16}$ inch, or a length of one-third the pitch. Now, while I think the old rule of seven-tenths the pitch quite superfluous, I should not go down to one-third, but for cast gears, where the mould is formed by a moulding machine and not by a pattern, which is likely to be warped out of true, I believe six-tenths to be ample, and for cut gears on stiff shafts, well held into *mesh*, eleven-twentieths, of which five-twentieths is the point of the tooth above pitch line, and six-twentieths the root, thus giving one-twentieth "clearance," instead of one-tenth as by the old rules. If the gears are true and held firmly in place, as proposed above, this should be sufficient. In case of pinions of from 11 to 16 teeth as mentioned by Mr. Klindworth, I think they should always be "*shrouded*," as the root of the tooth is necessarily cut away more than in a larger gear. Mr. Klindworth is correct in saying that two pairs of teeth should always be in contact, or that a second tooth should always "get hold" before the first one "lets go," and the instance he quotes, where a gear of 7 inches pitch had broken after a few months' work, when previous gears of less pitch had lasted much longer, is sufficient evidence of the truth of this.

I do not like pinions of less than 16 teeth, and had rather trust to one of 22 teeth and ½ inch pitch, than to 11 teeth and 1 inch pitch, if proportionately wider.

One statement of Mr. Klindworth's I do not understand. He says: "The wheel being cast iron and running at about 1,570 feet per minute, it will not be safe to go much over 1,500 pounds per square inch."

What are his data? Boulton & Watt, in their formula, took the breaking strain as 7,200 pounds per cubic inch, and one-fifteenth of that, or 480 pounds, as the safe strain. From Mr. Thomas B. West's tests, published in the *American Machinist*, I take the breaking strain of American iron as 8,000 pounds, and one-sixteenth of that, or 500 pounds, as the safe strain, which gives an ample "factor of safety" for "corner contact;" and working from this basis I get a pitch of 4 inches and a face of 10 inches to transmit 400 H. P. at 1,570 feet per minute, instead 5,75 and 17 inches respectively, as given by Mr. K.

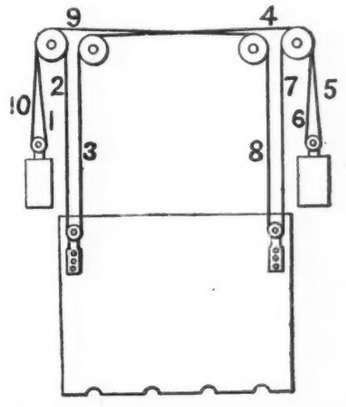
I may be all wrong, but have pretty good authority for thinking that I am not, as the rule of my old friend, the late Jas. B. Francis, gives the same result, although stated in a different formula.

I am much obliged to Mr. W H. Booth for his kind appreciation of some former notes of mine on this subject, and glad to hear that some English engineers are already looking into the same question.

* * *

CORE-OVEN DOORS.

The Straight Line Engine Company has its core-oven doors counter-weighted in a manner which insures both sides to go together without guides, as shown in the figure; the ropes being strung in as is indicated by the numbers.



* * *

WE are pleased to announce the formation of the Cox Computer Co., at Stapleton, N. Y., with Mr. Wm. Cox as president. They will systematically manufacture his well known computers, and their improved facilities will enable the prices to be materially reduced, thus placing them within the reach of everyone having need of such instruments and making their usefulness better known.

MACHINE SHOP ECONOMY.

CONSUMPTION OF SUPPLIES.

ROBERT GRIMSHAW.

There are many shops running to-day, the proprietors of which cannot tell the cost of any one item in their production, except, perhaps, labor, in a general way. There are others where the cost in each item or sub-item is known to a decimal point, and where the proprietors can detect a leak or a waste the first week of its happening.

In the matter of supplies, too many shops have a "go as you please" system or way. Every one is allowed to call for as much of anything as he choses to take the trouble to go for or send for. It is easy to see that in such shops there are many opportunities not merely for waste through carelessness, but for theft.

These establishments where the account is taken of everything that is issued to any one, and not only that, but even the amount to any one department or any one man, assure me that it pays them to do it, just as much as it pays a housekeeper to know how much sugar and how much butter is used per week and per meal, and how many pieces go in the wash each time from each member of the family, and how many come back.

In the Brown & Sharpe shops the system is at once simple and thorough. To commence with, in each department there is a blank, "cap" size, in which the supplies drawn by each workman are entered. The heading of one of these blanks (that for the tool room of any one building, the number of which latter is to be filled in) is here given. If there is suddenly a big run on some one kind of supply it will be known at once, so that if any man has a trick of washing his hands with waste and lard oil, or of pocketing Grobet files, it will be apt to be traced to him pretty quickly; and also if there is an extra run on any one kind of files it will be known, so that more may be purchased in time for that particular kind of work, or perhaps the work transferred to milling-machines or emery grinders.

There is another sheet in which the returns from the various departments are entered, as turned in by each, on the forms just shown. I show the heading here. In the left-hand column headed "Supplies" appear the following items: Lard oil, sperm oil, No. 1 cosmoline, No. 2 cosmoline, and naptha; the word "gals." appearing at the head of each of the nine following columns for these; then with the word "dozen" items, bastard, second cut, smooth and Grobet files, bench, thread and tin-handle brushes; then belt-lacing (— feet); next, with "lbs.," items solder, iron rivets, copper rivets and waste; then emery cloth (— qrs), next with words "ft. and in.," item "belting," six times. On each blank there is place for other departments or other items, should new ones be added.

TOOL ROOM.

No. BUILDING.

Consumption of Supplies by HELP for the 4 weeks ending _____, 189__

No.	NAME.	CANS OF OIL.			FILES.					
		Lard.	Sperm.	No. 2 Cosmoline.	Bastard.	Sec. Cut.	Smooth.	Grobet.	Bunches of Waste.	Sheets of Emery Cloth.

TOOL ROOM.

No. BUILDING.

Consumption of Supplies by DEPARTMENTS for the 4 weeks ending _____, 189__

SUPPLIES.	Basement.	First Floor.	Sec. Floor.	Third Floor.	Smith Shop.	Hardening Room.	Pattern and Flask Shop.	Foundry.	
	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.
Lard Oil.....									
Sperm Oil.....									
No. 1 Cosmoline.....									
No. 2 Cosmoline.....									
Naphtha.....									
Alcohol.....									

TOOL LISTS.

Not long ago I made another visit to the world-famous shops of the Brown & Sharpe Mfg. Co., and which for some reasons, and in some lines, there was less to learn there than in establishments where there is more building and less manufacturing, the science of making things in quantity, exactly alike, of the highest attainable degree of perfection, with the greatest capacity of production, and at the lowest cost, consistent with good work, the business of making the machine-tools as though they were sewing-machines, and milling-cutters as though they were buttons—to say nothing of the side lines of making sewing-machines by the hundred thousand—must of necessity call for special devices and systems, from which others may learn.

One of the predominent characteristics of this vast establishment is the business management which pervades every department, so that the visitor, while he cannot fail to be impressed with the fact that here unrivalled machine work is done in metal, is equally impressed with the other fact that such work is not done for love, but must produce a profit—all the profit of which is perceptible. It is the 5 per cent. savings here, there and everywhere that has enabled the concern to lower its prices on standard machines 50 per cent. in ten years, while keeping up and even raising the quality of workmanship and the quantity of metal.

One thing struck me—the profusion of both special and standard tools and appliances, and at the same time that all these were in perfect order and condition, and none of them thrown one side or laid down carelessly. Down to a cold-chisel, every man is charged with each tool that he gets, and not merely charged with it as "one cape chisel," but at a definite price thus impressing him with the idea that it is not merely so many ounces of steel, but something costing money, worth money and used for making money. This system is so much better than the plan employed in many large machine shops that even the very details by which it is carried out should prove interesting and profitable.

The tool list (copy of which is here given and is commended to the attention of machine shop proprietors who are not in business for their health) enables an accurate account to be kept of just what each man gets, returns, spoils or loses. The actual size is $3\frac{5}{8} \times 10\frac{3}{8}$ inches:

BROWN & SHARPE MFG. CO.

TOOL LIST.

DRAWER NO. ____

_____, 189__

Each workman is provided with a drawer with a lock, and will be held responsible for tools, at prices annexed.

No.	NAME.	Price Each.	No.	NAME.	Price Each.
	Lathe Board.....			Center Reamers.....	
	" Tools.....			Vise Clamps.....	
	Oil Cans.....			Cold Chisels.....	
	Bench Brush.....			Wood Mallet.....	
	Tin Handle Brush....			Brass Hammer.....	
	Thread Brush.....			Lead Hammer.....	
	Paint "			Drawer Key.....	
	Files.....			Check No.....	
	File Card.....			.....	
	Screw Drivers.....			.....	
	Hand Tools.....			.....	
	Scrapers.....			.....	
	Center Drills.....			.....	

Other tools needed can be obtained from the tool-room on leaving a check as receipt.

Tools to be delivered to the owner of check only, and must be returned as soon as possible, that other persons wanting them may not be delayed.

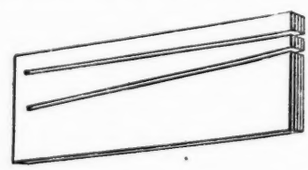
All damage or loss of tools will be charged to the owner of the check, unless such damage or loss proves to have been unavoidable.

It is comprehensive without being cumbersome; concise without being indefinite and ineffective.

I cannot too highly commend the idea of charging tools at a price instead of as mere pieces of metal.

MILLING OUT KEYS.

About as cheap a way of making keys in quantity, or even when only a few are needed, is to mill them out of a slab, by a cutter which is practically a thick saw. This insures that the sides which are at an angle to each other and which do the work, and hence require to be true and well finished, have a perfect surface and a regular taper—the latter being of whatever angle is chosen, and readily determined by the graduate table of the machine. From one slab, either planed off or milled on the two parallel sides, there may be milled a number of keys, "head and tail," the entire stock being used up if the width is rightly chosen. The illustration shows such a key partly milled out of the plate or slab.

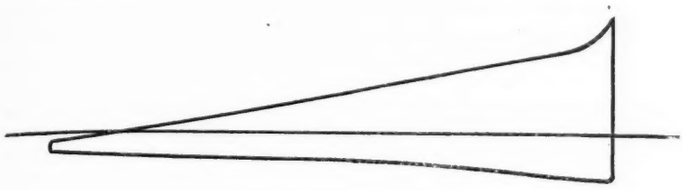


A CASE OF EXTRAVAGANCE.

WALTER B. SNOW.

The possibilities of economizing are no more forcibly exemplified than in those cases of extravagant waste which simply appall by their utter disregard of consequences, and in no way is the incompetency of those in charge more readily demonstrated.

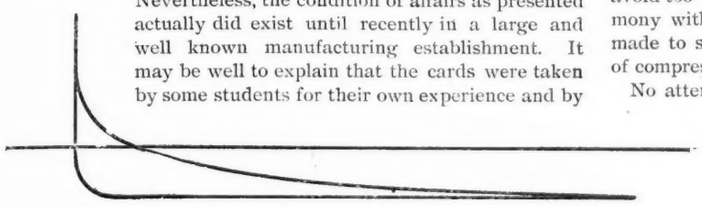
As the primary element in most manufacturing processes is the coal pile, it should above all first receive that careful attention which alone can bring about the highest economy in its use. In the hands of incompetent men it is likely to vanish far too rapidly through mismanagement of boilers and engines, through unprotected steam pipes and the uneconomical use of exhaust steam.



CARD A.

In these days of high grade engines and of well disseminated information regarding their economical operation, and the permissible limits of steam consumption under given conditions, such a case of extravagance as is here presented is entirely unwarranted.

Nevertheless, the condition of affairs as presented actually did exist until recently in a large and well known manufacturing establishment. It may be well to explain that the cards were taken by some students for their own experience and by permission, but not by request, of the management; consequently no direct and formal report was made to the parties interested, and the test, if it may be so called, covered only the taking of indicator cards with the accompanying observations. The diameter of piston-rod was not taken in either case, but as the conclusions to be drawn are relative this has been neglected, and the horse power figured the same for each end of the cylinder.

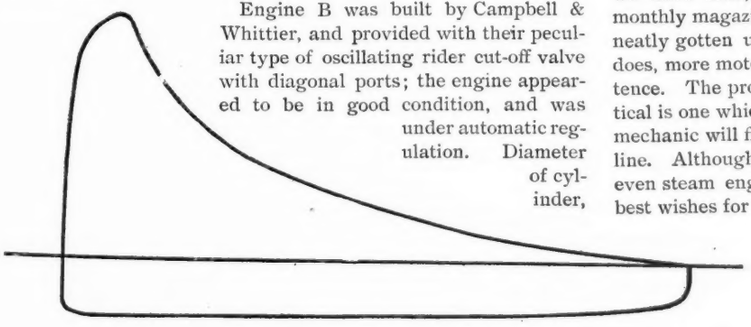


CARD B

The power plant proper, which is all that immediately concerns us, consisted of three engines, to be designated A, B and C, and of a Bulkley condenser producing vacuum for all three.

Engine A was of the slide-valve type with two valves, a main and a rider, the former with fixed and the latter with hand adjustable cut-off, the engine being fitted with a throttling governor. Diameter of cylinder, 14 inches; length of stroke 36 inches; 90 revolutions per minute. There were no piston rings in place, as they had been broken some time previously and none had been substituted.

Engine B was built by Campbell & Whittier, and provided with their peculiar type of oscillating rider cut-off valve with diagonal ports; the engine appeared to be in good condition, and was under automatic regulation. Diameter of cylinder, 18 inches; length of stroke, 36 inches; 80 revolutions per minute.



CARD C.

Engine C was of the Corliss beam type, with cylinder vertical and below the shaft, and was reported to have been purchased second hand; at all events it was in abominable condition, and vibrated excessively, while it was subject to great fluctuation in speed.

The engineer did not know the diameter of the cylinder, and the circumstances would not permit of ascertaining it by direct measurement. Its stroke, however, was found to be 5 feet.

Reproductions from sample cards from these three engines are presented under the same designating letters. All of the cards were taken with a 30 spring, and the average of the pressure readings were: Steam gauge, 72.5 pounds; vacuum gauge, 23.1 inches.

Card A figures out a mean effective pressure of 12.02 pounds and 30.27 H. P.

Engine B might just about as well have been standing still, as far as any practical result of its operation is concerned. In card B, from this engine, it will be noted that practically all of the work is done below atmospheric pressure, and by the vacuum produced rather than by the steam introduced. In fact, the mean effective pressure was only 3.33 pounds, while the power exerted amounted to only 12.33 H. P. How much of this power was expended beyond that necessary to overcome the inherent friction of the engine, any one with the least experience can judge.

Of engine C it is regrettable that its exact size is not known, but this card shows that only 22.62 mean effective pressure was obtained; so little, in fact, when the effect of the condenser is considered, that it is evident that this engine alone, if in proper repair, would certainly have been able to do in addition, the work being done by the other two engines. In point of fact, however, the engine was in such an unsubstantial condition that the admission valves had been set a little late to avoid too sudden admission at the end of the stroke; but in harmony with the rest of the plant, no apparent effort had been made to secure the same end by providing a reasonable amount of compression.

No attempt has been made to figure from the cards the steam consumption, as under the circumstances very little reliance could be placed upon the results as giving anywhere near the actual values, but there cannot be the least question but that the amount of steam consumed in engines A and B was far in excess of what would have been required to produce the same result in a single cylinder properly proportioned to the work.

The correction of these evils necessarily entailed expense, and because of the first cost this called for, the excessive running expense was allowed to continue at a rate far above the interest on any expenditure necessary to reduce it. But a comparatively small amount expended upon a re-arrangement of the shafting in such a way that engine B might do its share of the work, would certainly have brought large returns in economy of steam, while the slide-valve engine might possibly have been dispensed with. But although the management was made acquainted with the condition of its power plant, it had ears that heard not, and eyes that saw not, so kept on its old way in the process of squandering the money that might have gone far towards increasing the dividends of the stockholders.

* * *

ABOUT as good an example of "taking time by the forelock" (although perhaps we should say "by the steering wheel") as we have seen, is in the advent of *The Horseless Age*, a new monthly magazine of about 50 pages, 9¼x11¼ inches. It is very neatly gotten up and is extremely interesting, containing, as it does, more motor-carriages than most of us knew were in existence. The problem of making motors light enough to be practical is one which will continue to attract wide attention, and the mechanic will find this journal interesting and instructive in this line. Although a few electrical carriages are shown, the oil and even steam engines appear to have the advantage. It has our best wishes for a successful future.

The magazine is published and edited by Mr. E. P. Ingersoll, 157 William Street, New York. Price, $2 a year, 25 cents a copy.

* * *

Mr. Thomas F. Flinn, General Superintendent of the H. R. Worthington Co. has adopted a commendable plan for disposing of the many papers that collect in his office and most of which he does not keep on file. He has them placed at the doors of the shop just before "quitting time" and the men help themselves as they go out. In this way much useful information is disseminated and the result is sure to be beneficial otherwise. It is much better than destroying or selling them, or using them to pack goods as is sometimes done.

ENGINE ROOM NOTES.

TWO PLANS.

W. H. WAKEMAN.

The manager of a certain institution decided to put in a new engine. They bought one of suitable size and it was delivered on the premises where it was to be erected. They directed the engineer who was to run it to hire such help as he needed to erect it, and go on with the work. He complied with the order, secured some good laborers and under his direction the machine was set up. The foundation had previously been laid as he desired it to be done, and when the engine was moved into place piece by piece, every part was carefully and accurately adjusted to its proper position, a reasonable amount of time was taken for each separate part of the work, and, while no time was idled away, still no undue haste was allowed to interfere with the thoroughness of the work, for the engineer was ever mindful of the fact that if due care was not exercised in adjusting the several parts he would not only be blamed for it, but would also have the trouble and annoyance of correcting the mistake, or would have to get along with it as best he could.

When the engine was started up it operated quietly, there was no heating of the journals, and the work was satisfactory in every respect. In the same city where this engine was located, there was a factory where a new engine was needed, as the old one was outgrown. The engine builder brought the manager of this factory to see the engine that was running so nicely, and took the opportunity to enlarge on its good qualities. Said manager was highly pleased with what he saw and heard, the consequence being that he bought one of the same kind and also of the same size in every respect. The second engine was erected under very different conditions from the first one mentioned. The engineer who was to run it was what is sometimes called a "good runner," by which is meant that he could keep up steam, see that the water level was where it should be, keep his engine oiled, and keep the place in fair condition, but beyond this he knew nothing about the business, was not expected to, and I presume was paid accordingly. The manager, who agreed to take out the old engine and erect the new one for a certain price, which was satisfactory, and I presume that he did all that he agreed to do, and made all the money out of it that he could.

When the new machine was started up it afforded something of a contrast to the other one, for more heat was developed in the journals, and more noise was plainly heard in several places, and in short the whole job was far from being as satisfactory as the first one mentioned. I give these facts just as I find them, for this is not a fancy sketch, but is taken from real life. They fairly represent two different systems under which steam plants are run from the beginning to the end of every year.

The first case represents those plants that are owned by men whose time is too valuable to be spent in dabbling with work that they know nothing about, and have no time to spend in becoming proficient in. They hire a competent man to take charge of their machinery, pay him good wages for doing so, and hold him responsible for the economical operation of the plant, as well as for the careful maintenance of it at all times. They furnish such supplies as he needs, allowing him to select those that are best suited to the needs of that particular plant, and in short give him full charge as long as they consider him competent for the work, and when they have good reason to change their opinion of him, they do not try to run the plant themselves, but get another man in whom they have confidence.

The second case represents those plants where the manager assumes the whole responsibility for running the plant, and the so-called engineer is a man who is hired to do what he is told to do around the place, whose cares cease when the whistle blows, and who must work for about the same wages as a first class laborer. Whenever minor repairs are needed the man in the engine room reports them, but they are not attended to in time, and, when they can no longer be postponed, machinists are called in and proceed to do what the manager (not the engineer) orders, and this work is done either by the day or by contract, but in either case is not given the care and attention that it is entitled to, because no man understands a plant unless he has run it himself, and men are seldom really interested in work that they are not responsible for. To such an extent is this system carried in some places, that the engineer is not allowed to drive a key on his engine, but at stated intervals a man is sent from some engine-builder's establishment, who examines every part of the machine, keys up the places that need it, and then they must run until his his next visit. This is about equivalent to engaging a doctor to visit you once a month on general principles instead of coming when he is needed. Such a plan for operating a steam plant cannot produce the best results, for the simple reason that those who are in constant attendance, and consequently in the best position to care for the machinery, have no responsibility.

If the idea that an engineer should be allowed to run his plant and then be held responsible for it, is advanced to some manufacturers, they will ask you if you mean to allow the engineer to own the machine; and to this I would reply that if you want to get the most intelligent and valuable service out of him you must make him think to a certain extent that he really does own it, or at least is equal partner with you concerning it, and if he has the right disposition he will see to it that you do not lose money by your confidence in him, and if he has not the right ideas about such matters it would be a good plan to secure the services of of some one who has.

CALCULATING THE DUTY OF A PUMPING ENGINE.

The duty of a pumping engine is usually given by stating the number of foot-pounds of work that it will do while burning 100 pounds of combustible under the boilers that furnish steam for it, providing the pump builder furnishes the boilers as well as the engine, but if he does not supply the boilers he stipulates that they shall evaporate a certain amount of water per pound of combustible, in order to prevent the rejection of the engine on account of inefficient boilers. An illustration of the way that this duty is calculated will interest those who are not familiar with it.

The water cylinder of the pump was 24 inches in diameter, with a stroke of 38 inches. The boilers were of the ordinary return tubular type, and coal amounting to 8,358 pounds was weighed out and wheeled into the boiler room. A sample of this was weighed out, then thoroughly dried and weighed again, when it was found that where it weighed 100 pounds at first, it now weighed but 96.7 pounds, or in other words 3.3 per cent. of it was moisture. 3.3 per cent. of 8,358 is 276, and 8,358−276= 8,082 pounds. At the end of the test 196 pounds of coal and 543 pounds of dry ashes were left in the furnaces and the ash pits. Subtracting these leaves 7,343 pounds of combustible. It was estimated that 690 pounds of combustible was used in warming up the furnaces, and as they were hot when the test ended, it was only fair to deduct the coal burned in warming them up. There was a chance for a small error here, but it was the best that could be done under the circumstances, and the estimate was carefully made. This leaves 6,653 pounds of combustible actually burned in pumping water. We must separate this into units of 100 pounds each, as the duty is based on the consumption of 100 pounds of combustible, and 6,653÷100=66.53 units.

This pump took water from a lake the level of which was below the water cylinder, and a vacuum gage on the suction pipe showed 7.25 inches of vacuum, and as 2.04 inches is equal to one pound, 7.25÷2.04=3.5 pounds. This is to be treated as if it were so much pressure to be pumped against, or in other words it must be added to the pressure on the discharge pipe, which was 62 pounds by the gage and 62+3.5=65.5 pounds. In order to ascertain the head that this represents, it must be divided by .434, because each foot in height represents .434 pound, therefore 65.5÷.434=151 feet.

The area of a 24-inch piston is 452.39 square inches, and as the piston-rod is 3 inches in diameter, we must subtract one half of its area from this, and 452.39−(7÷2)=448.89 square inches. The stroke is 38 inches and therefore the water cylinder contains 448.89 ×38÷1,728=9.87 cubic feet. The water was nearly at the freezing point at this time, and taking its weight at 62.425 pounds per cubic foot, and raising it 151 feet high we have 62.425×151= 9426.175 foot-pounds for each cubic foot of water put into the reservoir, and 9426.175×9.87=93036.3 foot-pounds per stroke of the engine.

The test lasted 10 hours and 48 minutes, during which time 41,940 strokes were recorded by the counter, making 3,901,944,519 foot-pounds as a grand total.

We wish to know how many foot-pounds to credit to each unit of 100 pounds of combustible, and as we have 66.53 of these units, 3,901,944,519÷66.53=58,649,399 foot-pounds per 100 pounds of combustible burned.

Another way in which this may be calculated is to treat the water cylinder as if it were a steam cylinder, and calculate the work done in the same way, except that we would take the whole distance traveled by the piston instead of the feet traveled per minute as when calculating the power of an engine. The stroke is 38 inches and there are 41,940 strokes to calculate for, therefore $41,940 \times 38 \div 12 = 132,810$ feet traveled by the piston. We now have the area of the piston, the number of feet traveled by the piston and the pressure on the piston. $448.89 \times 132,810 \times 65.5 \div 66.53 = 58,694,104$ foot-pounds per 100 pounds of combustible.

Still another way in which it may be calculated is to find the gallons per single stroke, and by multiplying the area of piston by the stroke and dividing by the number of cubic inches in a gallon, we find that $448.89 \times 38 \div 231 = 73.843$ gallons per stroke. Now one gallon of water weighs 8.34 pounds, and in raising this quantity to a height of 151 feet, we do 1,259.34 foot-pounds of work. Multiplying the gallons per stroke by the foot-pounds per gallon and by the total number of strokes, and dividing the product by the number of units of 100 pounds of combustible, we have $73.843 \times 1,259,34 \times 41,940 \div 66.53 = 58,622,351$ foot pounds per 100 pounds of combustible. The slight difference in the results obtained is due to the fact that the fractions were not carried out indefinitely. However, as the greatest difference shown here is less than the work done by one stroke of the pump, I am sure that it will be considered a close calculation.

* * *

TOOL STEELS.—I.

B. E. D. Stafford.

The subject of tool steels is inexhaustible in its details, covering a wide field of research, inasmuch as it is the most important factor and still the least recognized in the process of manufacturing, where cutting tools are used to remove stock and shape the desired article prior to its assemblage as a finished product.

Years ago the tool steels we now call low grade were sufficiently good for all manufacturing purposes, and the purchasing price in those times was higher in proportion for quality given than for the steels now offered at the same price and far more durable.

Machine industries were few, their products commanding a price based on the manufacturing cost and a margin 50 to 75 per cent. higher than manufacturers to-day ever expect to get. A large portion of the cost was expended in keeping tools up to the work, and was an expense lost sight of owing to the fact that all tool dressing and work expended to sustain tools went into "Shop Expense," and the life and durability of tool steel, or the income derived from its use, could never be ascertained.

Ever since the war there has been a steady increase in the growth of our iron and steel industries, and in the last decade we have trebled our products and have won the distinction of being the greatest of manufacturing nations, and as regards the working of iron and steel into finishing products under the most approved methods of machine engineering and shop practice.

The rapid advance in steam engineering and the wonderful conception and universal adoption of electrical power, simultaneous with the advent of the typewriter and the bicycle and innumerable improvements in automatic machinery, taxed the capacity of our manufactories to such an extent that even to-day we are not fully prepared for a wholesome revival of business.

Where one mind was genius enough to conceive, a hundred others were fortunate enough to improve, and a multitude opened up a revolution in the manufacturing field on a strictly competitive basis, marking an era in progress that was phenominal.

The machine tool builders of this country were limited, and the increasing demand for their product far exceeded their capacity to supply and equip, necessitating a rapid growth in this field extending to all points of the continent.

The tool steel makers of the world easily demonstrated in their high grade steels, that the machine tools in actual service, or a large portion of them, were inadequate in strength and power to derive the results aimed for in the use of their steels.

Machine tools formerly considered substantial and perfect for all operations they were designed for, have constantly been improved. Special machinery embodiments of strength and power, beauty and simplicity of construction, in varieties applicable to all the operations practical in manufacturing, have been devised through the ambitious effort and eagerness of all to reduce the cost of the article machined. Great speeds are attained in proportion to driving and pulling power of the machine, and we are beginning an era of manufacturing where operations of the severest nature will be considered mere play compared to former attempts.

If we should stop for a moment and take into consideration the condition of our equipments as a whole throughout the factories of this country, we could but come to one conclusion from a business standpoint, and that is, that the biggest investment that could be made towards lessening costs on articles manufactured, would be to consign a large part of the machinery now in service to the scrap pile, replacing it with modern tools capable of withstanding speeds and feeds such as should be used gauged from the strength and efficiency of good tool steels.

So long as there is a machine in the market that will double the product of an earlier one, or a tool steel that will stand greater speeds and feeds and more economical to sustain, manufacturers can well afford to invest.

Tool steels to-day are manufactured for special purposes and differ from the tool steels of years ago, when you could from the same bar make chisels, taps, reamers, punches, etc., and get satisfactory results, based on the methods then used of manufacturing and the varying degrees of heat for forging as well as hardening, offering no annoyance to the tool dresser. But they lacked the toughness and durability of the special steels now made which cover a large field, with grades of temper, or points of carbon, suitable to the requirements of different tools.

A great many toolsmiths advocate and use steels they have been accustomed to handling for years, because it requires less care as to treatment, and they are sure as to their results in forging and hardening. What do their results amount to compared to the working result of the tool when put to use? If by using a little care in treating a special steel such as is recommended by its maker for a given purpose, and that tool does double the work if not more, it surely demonstrates that it gives him less annoyance to sustain and keep it working, proving a good investment for both him and his employer.

Toolsmiths do not differ from machinists in some respects, inasmuch as old methods are adhered to on the grounds of certainty, placing no confidence in their ability to succeed with other methods advancing with the times. It is astonishing to many, who have confidence in high grade steels and have given their attention to its proper treatment, of the wonderful results that can be attained by its use, at the same time giving less trouble at the fire.

The proper forming of cutting angles and the proportioning of tools to do severe work is a point of the utmost importance to the success of any steel, and one that is neglected by scores of machinists who have not considered the relation of both; consequently the importance and efficiency of the steel is lost through improper construction of tools, and the steel is naturally condemned. This point particularly has been overlooked in the use of self-hardening steel, a steel that has been in use for twenty-five years, accomplishing wonderful results where fast speeds and coarse feeds were resorted to and hard and tough metals removed. One third of the tool-dressers of this country to-day are afraid to forge a self-hardening tool through lack of confidence in their knowledge of the treatment, and there are as many machinists who fail to accomplish the result claimed by its use in grinding angles too acute for the nature of the steel to stand.

Toolsmiths and machinists are invariably handicapped through the efforts of their employers to confine them to cheap steels. A great many manufacturers imagine the toolsmith capable of sustaining such steels by certain "tricks of the trade," in the nature of dipping solutions and carbonizing elements, which no doubt give excellent results over legitimate methods used on such steel, but they don't figure that the time taken to accomplish this, if cal-

culated into dollars and cents, would buy a steel that would not only do the work better, but would require less subsequent expense in redressing and hardening.

It is unreasonable to suppose that high grade steels should be used for everything, but when we enter into shop practice where machinery of the best type and modern methods are used to increase production and lessen cost of articles manufactured, the best steel should be used without regard to its first cost, or else the end aimed for will never be accomplished. Some manufacturers claim that if a good tool steel pays on heavy work, it pays equally on light work if properly put to the test.

In the handling and working of high grade steels, either at furnace or forge, the toolsmith will necessarily have to depart from his old methods somewhat, or very unsatisfactory results will follow. Small fire-brick furnaces are inexpensive and highly commended where a large assortment of tool steel has to be heated

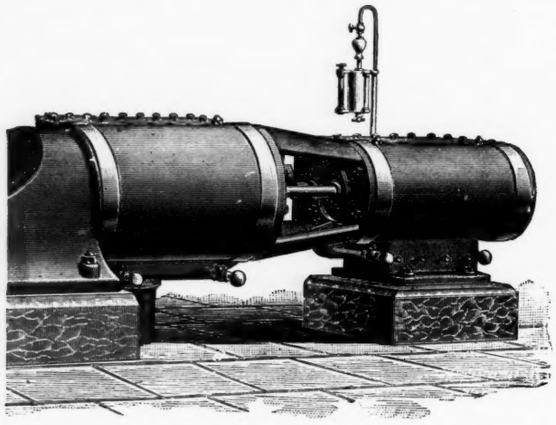


Figure 1.—See page 95.

for hardening, and better results have thus been obtained in heating for forging. Nothing but the best of fuel should be used in the treatment of tool steel, such as clean hard coke, charcoal and hard pea coal. When using coal, burn off the gases and top the fire with coke or charcoal.

The most disastrous results obtained in the use of high tempered steels is traced to the first operation, that of heating. It should be heated slowly and thoroughly, forged at a clear red with rapid blows and not too cold, keeping the metal to as even a heat as possible until finished, and then before reheating for hardening, it is well to let the forged tool cool down to allow the steel to assimilate under forging strains to its natural structure.

In heating for hardening, heat uniformly and clear through, using a slow fire and harden at low red. The lower a high grade steel is heated to harden it and the hardness is sufficient for the work required of it, the tougher and stronger remains the steel for subsequent redressing, the structure being less disturbed and the water cracks are less liable to happen through successive baths.

Some tool-dressers will heat to a bright red and then wait until the heat runs to a low red before dipping, and then wonder why they crack the steel. The outside surface cools faster, leaving the interior the hottest, and, when dipped, the unequal contraction, owing to the difference in heat, results in a tremendous

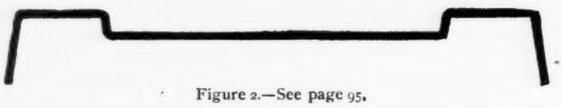


Figure 2.—See page 95.

strain and opens the steel; therefore in all grades of tool steel it is always a good rule to heat slowly and thoroughly to the color necessary to harden properly, and on the rising heat quench and harden. Temper should be drawn by slowly heating, and decided by file test to arrive at best results, but particular attention should be given as to extreme hardness before drawing.

Good clear water and plenty of it is necessary as a plunging bath, and it should be replenished constantly in a tank with inlet and outlet piped for constant service, with chill taken off, and where tools have to undergo great strains and repeated hardenings, a standing bath of salt and water will be found desirable. It hardens the steel at a lower heat, penetrating more rapidly.

NOTES FROM NOTOWN.—6.

ICHABOD PODUNK.

The other day I saw a young fellow, well dressed in a new hat and a good natured smile, coming up the shop, and the first thing I knew he reached out his hand and said "Hello, Podunk, still at the lathe, I see;" and I recognized young Jim Flinders, that used to be foreman in the shop across the street. I knew he hadn't been there for about a year, and wondered what had become of him. "What are you doing, Jim?" I asked; "guess you must be making money, by the looks of that hat, etc." "Well," said he, "I'm selling books. Funny business for a machinist, isn't it? But it's just this way, Podunk; I had to get out of the shop to make any money. You know I was foreman across the street here, and it broke their heart, which is closely related to their pocket-book, by giving me $3.50 a day as the top notch, and they couldn't think of paying a shop-man any more than that. Perhaps its all right and perhaps not, and so far as the actual labor is concerned, I might not have earned any more. But on that engine contract they had, the tools I devised and the methods I adopted saved them over $2,000 in cold cash; which went to the credit of the good management of the office, and the shop didn't get any credit, nor I any cash on account of it. Firms don't recognize that brains are just as much needed in the shop as in the alleged business end of the concern, or that ability is needed and should be paid for. Brains are just as valuable when they exist under a greasy cap and inside a man with a dirty face as in the drawing-room or the office, the only difference is in the remuneration. One gets it and the other don't."

"I'm selling books because I can make more money than I can in the shop, and yet it makes me itch to get at it again when I go near one, and I live in hopes that some day a concern will give me a chance to go back to it, by realizing that it is economy to pay the man who can save them money in the shop, just as good a salary as though he wore patent leather shoes and a neck-tie."

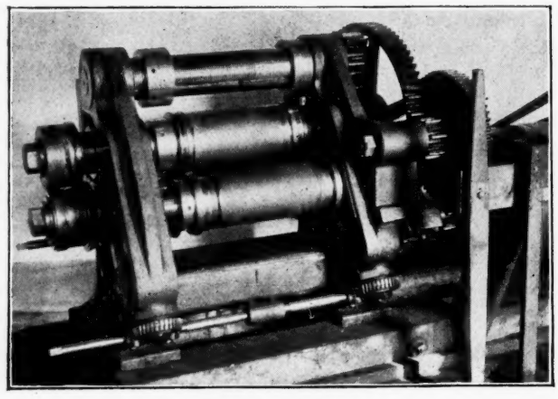


Figure 3.—See page 95.

He told me of his trips and the things he saw, but I can see he longs for the shop. The more I think of this the more truth I see in it; and though I don't think of selling books myself, there is too much truth in what he said. And I think the economy of a good salary to a superintendent, or a foreman in small shops, will be recognized more and more, of course providing he is worth it and has more of a claim to it than "length of service," or "knowing where things are kept," as in some cases I know of. It is surely just as praiseworthy to save a dollar in construction as to gain that amount by squeezing a customer a little on the discount.

SPEAKING about foremen and superintendents brings to mind several of them who don't deserve a high salary; in fact no salary would repay their service, but still lose money for the firm. A good man is cheap at a high figure; a poor one is dear at any price. These positions are too often filled by relatives of the firm, regardless of other qualifications, or those who can "get along with the men," whether their work is economically done or not. Many of the recollections of the ignorance of foremen and others in authority are amusing and make good stories, but they also tell the story of financial disaster and final extinction of more than one firm, and a shop of this kind unfits a man for doing good work in shops that are run on an economical basis.

It can be safely said that a man who is to superintend the work

in a good sized shop should be a good mechanic, should be quick to devise better methods and to see good points as well as defects in the plans of others. I know of only one instance where a successful manager was not a good mechanic, and he had the sense to surround himself with good mechanics, to ask their advice, abide by their decisions, and last but not least, *give them credit for it.* A man rarely possesses the combinations of good sense referred to, and is a decided exception to the rule. When the men find the

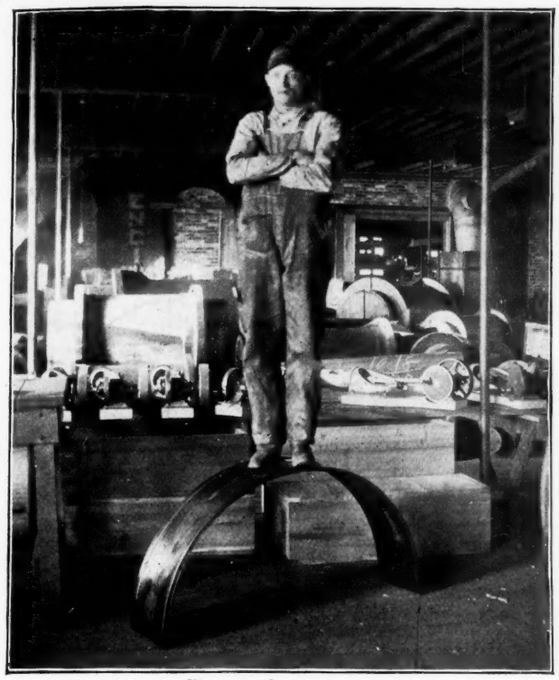


Figure 4.—See page 95.

foreman in charge is not fitted for the work and is not posted on the various kinks in common use, each one knows he is just as well fitted for foreman as the one who has the position, and is not apt to help him as much as he might. A foreman of this kind cannot have much control over the methods of working, as he is not a thorough mechanic and the men know it. He has no good means of judging as to the proper amount of time for each job, and as a consequence he is not securing a good output from the plant—in fact is losing money and preventing some good man from saving it.

As an example of this it may not be amiss to cite a few instances which have occurred in my shop experience, and are not fairy tales by any means. Calling the superintendent A and his assistant C, I can say that C was hired solely for his *lack of knowledge* and his inability to supersede A in case anything went wrong between A and the firm, and C filled the bill to perfection

In setting up an engine the men couldn't get the pumps to work, and depended on the injector to fill the boiler, trying all the while to locate the trouble. Finally, after taking the pump apart several times, it was found that the auxiliary check-valve was missing, so that the water from pump simply went back through injector to tank again. Detecting a rattle in the pipe they took it down and found the missing valve; but how did it get there? Inquiry at the shop found a man who helped C put it up, and the way he told it was something like this: "Misther C got the pieces all up but the injector, and finally whin he got that in place he had wan little piece left, so said he, 'Well, this bloomin' thing b'longs somewhere in 'ere,' and he chucked it in the pipe, laving it for the men on the road to fix." And that's just what he had done, showing a high (?) grade of mechanical ability, and a good idea of economizing time. This is only one of the many bright mechanical ideas he displayed, and it is pleasing to note that he is now working at the bench and earning little more than laborer's wages; but it's all he is worth, and appears to sort of even things up.

Mr. B gave us a good lesson the other day on the necessity and economy of having engines right before they leave the shop. We were rushing to get it shipped, and among the men was one who had evidently worked for one of these "hustle or bust" men, which should usually be read with an "and" in place of "or." He found that some of the studs which held the gland on the air pump rod had been threaded a little too small—in fact had a good sized "shake" in them—and he was about to make them "fit" by smashing the threads with a hammer, when Mr. B spied him. "Hold on there, Jim, what on earth are you trying to do?" "Make these studs fit," said Jim; "haven't got time to get any new ones made." "Well, we'll take time, then, but no such work goes out of here, hurry or no hurry. What do you suppose an engineer would say when he took that apart to see why the studs were loose, and they would be loose in about a month? He'd say, 'Well, if this is the kind of work that the Notown Mfg. Co. do we don't want any more of it,' and I wouldn't blame him any, either. You must have worked for Mr. Rusher, I guess, but we'll go slower and have things right, and in the meantime I'll find who is responsible for this poor work." "Well, to be candid," said Jim, "I am. I was in a hurry, and as I've been used to 'fixing' work so it would hold till it got out of the shop, I didn't take as much pains as I might have, but you've taught me a lesson and I'll be more careful hereafter, for I can see how such work hurts a shop." Mr. B didn't even charge him for spoiled work—said he had learned his lesson without, and that was the main thing. There is too much of this kind of work done, generally without the superintendent's knowledge (although not always), and usually encouraged by some smart foreman who wants to make a big showing for his department. Slighted work of this kind is sure to be discovered sooner or later, and the purchaser always feels as though he had been cheated, same as you do when you find a shoddy sole on your shoe.

This recalls another incident of a similar nature. Another engine was being hurried along, and as some of the keys were a little large, the man in charge left them sticking in as far as they would go, thinking the erecting man would fix them. "How long will it take to fix them here?" asked Mr. B. "About half an hour," was the reply. "How long will it take Frank to fix them in that little town in Kentucky, without any machine shop?' The man didn't know. "Well, about ten times as long, as he has no facilities there. The men are in a hurry for the engine, and will think it's a funny way to do business if our man does the fitting there. It's cheaper to fit things right before they go out, takes less time, less labor and don't give the idea of an experimental establishment where we don't know how the work ought to be. When work leaves here it must fit, and then it will be sure to fit when it is put in place."

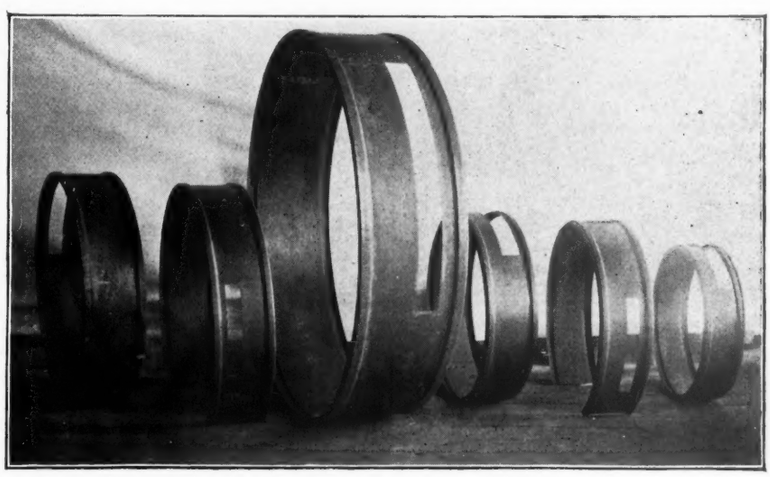


Figure 5.—See page 95.

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Cutting Speed of Lathe Tools.—In calculating the number of feet per minute at which a lathe-tool is cutting, measure the perimeter before the cut and after, and multiply the mean of these two measures by the number of rotations per minute.

A FAULTILY DESIGNED WHEEL.

PETER H. BULLOCK.

It is often said that a good word should be spoken for the bridge that carries one safely over, and I suppose that as a matter of taste or courtesy it is proper to do so. On the other hand, as a matter of ethics, one should not speak in commendation of a bridge that he knows to be unsafe, even though he may have many times passed in safety over it. On the former basis I should have nothing to say against the wheel herewith illustrated, for it revolved in an engine room of which I had charge for over thirteen years, and without accident to it of any kind.

In this case confidence did not increase with years of faithful service, and the wheel was put into its present position of desuetude to satisfy my feelings of distrust that were founded on nothing but belief in its structural weakness. The pulley is 9 feet ×24 inches, and was located on and belted to, a main line of shaft from a 150

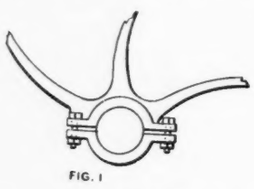


FIG. 1

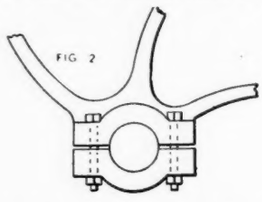
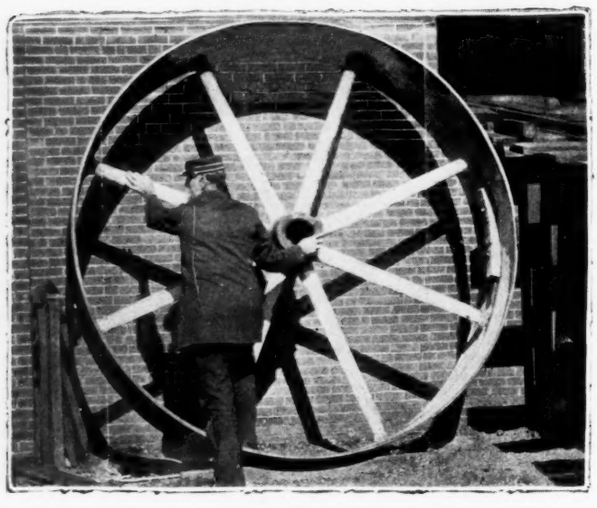


FIG. 2

HP. engine. The hub is bored 7 inches and is cored out in the center so that at the base of the spokes the metal does not average over 2¼ inches in thickness. The fact, however, that caused me to lose confidence in its stability was the spokes or arms, which are of altogether too small cross section and also too uniform in size from rim to hub, being an oval 3⅜×1½, with a cross-section of 4.3 at the rim and 4¼×1⅝ and a section of 5.4 at the hub. The comparative size of the spokes are well shown by the hand of the person standing in front of the wheel, whose native and acquired modesty and bashfulness impelled him to face the circumstances and present a back view for publication.

The first time the wheel ever gave the writer any uneasiness was when a workman swung himself from it to the floor, and as he let go of the rim I noticed a vibration. I was somewhat sur-



prised and immediately took hold of the rim and gave it a few vigorous shakes, and my surprise increased in proportion to the vibration, which by measurement was about one and a half inches. I have no reason to suspect that there was any spring in the direction of the work, but felt that a shock at right angles to its axis of rotation would prove disastrous to it. I also believe that I could have taken hold of the rim at any time and got it into a vibration that would have fractured it, the weight of the rim being excessive in proportion to the strength of the arms. At any rate I always desisted in experiments in that direction, through fear of such a result, long before the limit of my shaking abilities had been reached.

A good many split pulleys of the smaller sizes are also of faulty design, not only in details of structure, but offending the eyes of those who like to see things right at all times and especially when it is just as easy and cheap as when made wrong.

Figs. 1 and 2 show the ideas better than words. No. 1 is from a pulley 34×12×2 $\frac{7}{16}$. The bolts are 2 inches long, 2½ inches from the shaft, the ears or lugs are ⅝ inch thick and the hub 1 inch. Fig. 2 is from a pulley 36×10×2 $\frac{7}{16}$, the bolts are 1 inch from the shaft, 4½ inches long and the lugs 1¾ inch thick. Any one can see that No. 2 is the proper design, and that it will more surely run true on the shaft than No. 1. Perhaps all are not aware how much a split pulley can be made to run "out" by improper bolting. Of course if a pulley is bored and turned true it can be put on to a straight shaft and made to run true, but this does not alter the fact that pulleys designed like No. 1 can be, and quite often are, put on so as to run very badly. This is because the hub bolts have so great a leverage that those on one side, if tightened up unequally, cramp the hub out of true so much that the opposite bolts cannot pull it back, and the result is a bad running pulley and frequently a broken lug. With a stiff, heavy hub like No. 2 these things will not occur.

Nothing has thus far been said regarding the rim bolts, but the same rule applies there, for the lugs should be heavy enough so that the rim may be bolted up solid, and by the way, this should always be done first, or before the hub bolts are tightened.

Let everybody insist on having the proper design, and very soon there will be no other kind offered.

* * *

GEAR-OLOGY.

AN OBJECT LESSON.

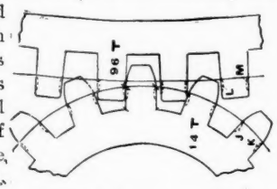
F. W. CLOUGH.

Whatever serves to teach the correct construction of the teeth of gearing, if it is in part by observing the action and points of incorrect contact of the teeth of ill constructed and improperly mounted gears, contributes to that end of information. The cut is an object lesson on this line, and is a copy of a pair of gear wheels, 14 and 96 teeth, which did service on a heavy derrick for years, in the yard of the ———Co.

The pinion of 14 teeth was the driver, and the wheel of 96 teeth was the one driven.

We note that the wheel of 96 teeth had teeth which in form were nearly straight and square pointed ends. The teeth of the 14 toothed pinion had curved faces, but the flanks were straight, and the tooth from pitch-circle to bottom of space was nearly parallel in thickness; X-X-X-X.

The form of the teeth, especially those on the large wheel, presented (when the gears were first mounted) to be set so that the pitch lines would come together, as they do in correctly constructed and properly mounted gears. Observe that the pitch lines are apart; observe that as the derrick was used and the gears wore in the hard service required of them, the especial points of contact wore out recesses, as are indicated in the cut at J K L M.



I passed by this pair of semi-conjugal co-laborers occasionally for several years, and nearly as often noted their condition, thus "mismated," in service, held rigidly to act when required to do duty as best they could in harmony with their "make up" in form. One thing was in their favor—evidently they were made of good "stuff" (strong iron); for they did service for many years and never broke down, nor "backed out" from work; but it took very much more power to run them than if they had been properly formed and correctly mounted. Recently I passed that way and my noted co-laborers were gone; a new and more modern derrick with doubtless better (in form of tooth) gears has taken its place; but perhaps I may question whether the new pair are of so good material as the old ones were. At any rate the old pair did a great amount of work, even if in part they were "mismated." Now we learn this: to construct the teeth of gears so that they will not only stand up in service (good material), but that they may wear well, as they wear, and thus will not require an unnecessary amount of power to drive them.

* * *

Locomotive Engineering has added to its efficient staff, and Mr. Orville H. Reynolds, late of the Northern Pacific R. R., connects himself with the working force, in charge of the Car Department; Mr. F. M. Nellis assuming charge of the Air Brake Department, and these additions assure a better paper than ever.

THE MECHANICS' FAIR.

The centennial exhibition in Boston, Mass., of the Massachusetts Charitable Mechanics' Association is a very creditable one, and shows that their customary enterprise and energy have not abated. The exhibit of machinery is in the basement, and here the writer spent his limited time.

The Norton Emery Wheel Co., of Worcester, have a neat exhibit, whose leading feature is their new universal grinder, which comes nearer to deserving that name than some of the machines which bear it. It is of simple design, and although it has numerous attachments there is no complication, each part doing its allotted duty in as easy a manner as possible. It is of the hollow column design, the interior forming an excellent place for wheels and attachments. The grinding bed swings around the columns and can be set to any angle, so that wheels can be used on their sides or faces as is most convenient, and this is a necessity in some grinding. The internal grinding attachment is especially convenient, and is one of the neatest devices for this work on the market. It can readily be swung out of the way for inspecting or gauging, the hole being ground and as readily swung back to the work, coming back to the same position every time without any adjustment. This has a very long bearing, and is so closely fitted as to necessitate the use of kerosene oil for a lubricant, there being no room for a heavier oil. This machine has a wide range of speeds, varying from 2,100 to 20,000 revolutions per minute, the latter being used for internal grinding with very small wheels.

In the same enclosure with the Norton exhibit are several of the Lodge & Davis tools, which are so well known, among them being a radial drill and several lathes. These tools are too well known to require any description.

Across the aisle from this is rather a novel lathe, called the Childs' Automatic Rapid Lathe, built by the Blanchard Machine Company, 303 Congress street, Boston, Mass. It is a very heavy lathe of 16-inch swing, having two driving belts, each 2 inches wide, running 1,350 feet per minute, transmitting about 6 HP. Spindle bearings are $3\frac{7}{8}\times4\frac{1}{4}$ inches and $2\frac{7}{8}\times4$ inches long respectively, and the spindle has a $1\frac{15}{16}$ inch hole through it. The weight of the lathe is 2,700 pounds, which gives an idea of its proportions. When the tool is moved to or from the center, the speed of the work varies so as to keep a constant speed at the tool, which is quite a time saver on work of varying diameters. This relation of speed to position of tool is automatically maintained with both hand and power cross feed. The limit of variation is from 8 to 175 revolutions, a range sufficient for ordinary work. The speed is easily varied by a small index lever, and the operator can stand in his usual position and watch the tool, increasing the speed as much as the tool will stand, and this speed will be maintained regardless of the diameter of the work. The feeds can be instantly and accurately changed from $\frac{1}{48}$ inch to $\frac{5}{16}$ inch per revolution by an index. The lead screw is placed inside the bed, out of the way of dirt and in a position to avoid the twisting pull which so often occurs. The lathe can be set either parallel or at right angles to the counter, which is a very desirable feature in many cases.

The Hendey Machine Co., of Torrington, Conn., have a fine exhibit of shapers and lathes, which will do much to convince a mechanic of the handy and desirable features of their tools. The fine adjustment of the stop controlling the forward stroke is especially useful in a large class of work, as it can be adjusted to any degree of nicety required without stopping the shaper. The feed which controls the vertical movement of the head is very effective and convenient, and as readily adjusted as the reversing stop. They are shown at work on cast iron blocks, which gives an idea of the cuts they can carry.

The well known Hendey-Norton lathes are also in abundance, and their good points are not hard to find. The screw-cutting device, which does away with all change gears, is fast becoming better known, which is equivalent to saying better liked, for no one can use it without appreciating the ease with which a change to cut any thread can be made.

The Gisholt Machine Co. and the Niles Tool Works have an exhibit of heavy tools in charge of Mr. F. H. Robinson, who kindly showed the writer some of the many good points of the machines, especially the Gisholt, which he represents. These turrets were among the pioneers in the line of heavy work and have done much toward reducing the expense of manufacture in many lines of machine work. Their various good points are well worthy a close examination by any one who wishes to keep posted on modern machinery. The carriage tool post of this machine is very useful in many cases and has the merit of being rigid, a feature too often lacking in this part of a lathe. The inclined turret allows the pilot wheel to be brought close to the front of the lathe, as the turret tools swing clear over it. The Gisholt lathe and planer tool grinder is as handy a tool as any shop can have and will do any work that an ordinary shop requires. The economy of having standard lathe and planer tools is being appreciated, and this machine is sure to be a favorite.

In the line of steam engine novelties was the Altham Steam Turbine of the New England Turbine and Fuel Co., 53 State street, Boston. The one exhibited is rated at 12 HP., is 17 inches long, 14 inches wide, 10 inches deep and weighs 200 pounds. It was said to be running 11,000 revolutions per minute and driving a dynamo at 1,100 revolutions. The reducing mechanism is quite ingenious, consisting of a long pinion, internal gears, etc. This is one disadvantage of extremely high speed motors, they require a great reduction of speed which is as bad as the gearing up necessary with slow speed engines. The men in charge declared they had obviated back pressure and obtained a very high efficiency in steam consumption.

Another candidate for the favor of the mechanical public is the Morse Rotary Engine, of P. O. Square, Boston. These engines are said to be in use by the navy department for lighting purposes. They run at from 600 to 1,500 revolutions per minute and are made from 4 to 150 HP.

The H. N. Bates Machine Co. have an attractive exhibit, one noticeable feature being the four valve engine of the Erie City Iron Works, Erie, Pa.

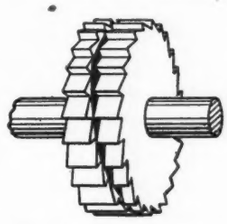
A very large hide was shown by Mr. Chas. L. Ireson, of Boston, the weight of the steer being given as 3,400 pounds live weight and 2,200 pounds of dressed meat. The hide weighed 186 pounds, green, and 105¼ pounds, tanned, and measured 11 feet 3 inches by 9 feet 5 inches, or 108 square feet.

The Wellington typewriter, which was new to the writer, is a very compact little machine and does good work, with no apparent reason why it should not maintain its alignment, as the type bars move in straight lines, guided on a horizontal steel plate, and as the type are on the end of the bars, which strike in direct manner. The writing is visible even to the last character struck, which is a desirable feature with many, and even old operators notice a relief after becoming used to the visible writing.

* * *

HANDY MILLING CUTTER.

There are many jobs of plain work for which it often does not pay to make a special milling cutter, so they are done on the planer, although not so well. It is, however, possible to have some cutters that can do a variety of work, or at least which will work to more than one size. Of course every one is familiar with the "built-up" cutter for O G and similar work, and knows that more than one combination may be made of the sections of such cutters, in shops having much milling to do; but I have not seen in as many shops as I should, "packed out" cutters like that shown here in the sketch by which several widths, within a certain range, may be milled by only changing the packing.



The two parts (which need not be alike) have their faces on one side at right angles to the axis, and the other, inclined at an angle of say ten degrees. The thick or wider side of one and the thin or narrow side of the other being brought together on the axis, with a packing-piece of leather, or other material, between them, the cutter will mill a width equal to the sum of the widths of the thick and the thin face, plus the thickness of the packing. The narrowest that this combination will mill is equal to the width of the two when put together without packing, and the widest cut they will make is equal to that, plus very nearly the difference between the wide and the narrow side. That is, if the cutters are alike and have widths of three inches and one inch respectively, of adjacent cutting faces, they will mill four inches as a minimum and very nearly six as a maximum, the range between varying by an amount as small as the thickness of a single sheet of paper.

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THIS PAPER HAS THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

DECEMBER, 1895.

THE increased size of MACHINERY and the additional work entailed thereby have made necessary a change in our editorial force; Mr. W. H. Wakeman retiring this month and being succeeded by Mr. S. Ashton Hand. The pressure of Mr. Wakeman's present duties together with his recent literary work, we regret to say, prevent him from giving the amount of time to MACHINERY which is now a necessity.

* * *

SOME recent remarks by a contemporary show that the competition hurts. There's room for us both, neighbor.

* * *

INVENTIONS—GOOD, BAD AND INDIFFERENT.

In too many cases the only excuse for the invention of new engines, valve motions, balanced valves and similar articles seems to be the desire to have something different rather than something better. As a matter of fact they are seldom very different in general idea, a slight variation on some detail being the new feature. But allowing that they are entirely new, the question to be considered is, are they of value? This does not mean, Will it do the work, but rather will it work better than anything we now have? The mere fact of its working, without breaking down or killing anyone, is not an infallible sign that it is a valuable invention. There are hundreds of devices in use to-day which are running fairly well and doing their work with little difficulty, yet which would not be bought at any price in the open market, the secret of their success being that they are fostered by some official who has invented them or who is interested in their financial welfare. Railroads are especially prone to this form of invention, and many a road is groaning under the wrong side of the balance sheet on account of some such device.

New engines are invented which combine various ideas and which will run when watched by the inventor's tender care or perhaps without it, but which would not survive the test of the open market, not because they are useless, but because there are others which will do the work as well or better, and which are simpler, easier to take care of and cheaper to make. There is no test that so soon shows what a device is worth as to put it on the open market in competition with other devices of the same kind; and though the prevailing mechanical verdict may not always be absolutely correct, it is far more to be depended on than the judgment of the inventor.

The first object of an invention should be to improve on present practice, not merely to change it; and because the new idea will work is by no means a sure sign of its being any better. Unless it shows an improvement sufficient to warrant change, even if there is no additional expense, there is little use in organizing a company to manufacture the device.

Men are too apt to compare the results obtained from these devices with some poor machine with which they are familiar, instead of selecting the best device in existence for comparison, and this seems to be especially true of valve motions and engines. For example, a new valve motion will be said to be as good as the Strong, instead of comparing it with the more simple and more reliable link; and an arrangement of compound engines with interior and exterior packings, annular cylinders, etc., etc., is very apt to be claimed as better than some other device which perhaps has more *bad* features, instead of being compared with the best arrangement in use.

The survival of the fittest holds good in mechanics as a rule; and as even the strenuous attempts of a large concern to force an unmechanical device on the market are sure to prove unavailing after a few years' trial, inventors of new and wonderful devices, as well as manufacturers, will do well to heed the advice of practical mechanics, instead of spending hard earned dollars in vain.

* * *

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THE INERTIA GOVERNOR.—(2.)

J. BEGTRUP.

A certain relation of centrifugal force and motion of governor weights was considered in my article in the November issue, the conditions were shown to be different in inertia governors, and an attempt was made to give the reader an idea of the difference in efficiency, which should be expected from both forms of governors. But it should be observed that the *general* relation of forces and motion of governor weights is of a more complicated nature, not generally understood.

Although the first movement of the weights directly after an increase or diminution of load, which was considered in my last article, is of considerable consequence in regard to the following "instantaneous" variation of speed, such movement bears no direct relation to the state of dynamic equilibrium which must exist in all governors. By "dynamic equilibrium," is understood the tendency of the governor to promptly return to a state of inactivity or relative rest, after it has been put into momentary action. It is a common mistake to consider the motion of the governor weights as a single movement from one fixed position to another, for while such is barely possible, it cannot represent the natural or general condition of motion, for the governor weights or any other weight cannot be put in motion and then stopped, either suddenly or slowly, before the impelling force has ceased to act or a greater resisting force has been applied. We cannot put a body in motion without imparting some velocity to it and cannot bring it to rest without a resistance, as for instance, friction. To bring a body into motion we must overcome its inertia and to bring it to rest we must destroy its kinetic energy, or *vis viva*. To apply this general principle of motion to a governor weight, let us suppose it to be at rest relatively to the governor in a certain position where it will cause just the proper amount of steam to be cut off in the cylinder corresponding to the load on the engine. Now let some load be suddenly taken off and a slight increase of speed will be the immediate result, followed by a momentary increase of centrifugal force, which will cause the centrifugal weight to move out from the center of the governor. In a short time it has reached a position where it would allow sufficient steam to enter the cylinder corresponding to the diminished load, but the weight does not stop there; what should make it stop? The speed has been increasing all the time since the load was thrown off and the weight commenced to move, and when it reaches the position where it ought to stop the impelling centrifugal force is greater than ever. It will, therefore, move past that position and cause steam to be cut off still earlier in the stroke. The speed will then be retarded and the weight will, under the action of friction, soon come to rest. But it cannot stop long there, for the speed is now decreasing and the centrifugal force also, the weight must, therefore, move back in the opposite direction, in short the weight is oscillating; it follows the law of oscillation, which is the natural motion of a governor weight. The oscillation of governors of the vertical fly-ball type can readily be observed when a sudden variation in load occurs; and if it is a shaft governor with an eccentric of variable eccentricity on the outside of the governor wheel, which is now a common arrangement, the oscillation can be shown graphically by a simple device. Insert a steel point in the eccentric and put a stand in front of it, and on this a piece of tin fastened vertically to a slide; when this is pushed against the steel point, there will be a circle described on it, and when part of the load is suddenly thrown on or off there appears a number of spirals crossing each other, finally coalescing into a circle, which represents the final position of the eccentric at relative rest. The spirals extend on both sides of this circle and are an unmistakable proof of the oscillation. Care should be taken to load the engine sufficiently so as to prevent the stops on the governor from interfering with the oscillation. If the load is applied slowly the oscillation may become so reduced as to be hardly noticeable.

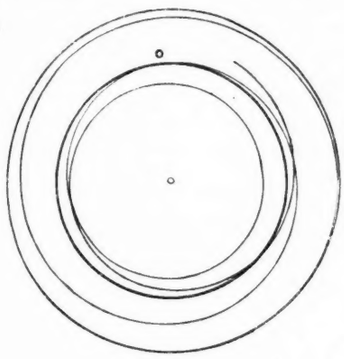

FIG. 2

Now the necessary condition for dynamic stability in a governor is that the oscillation shall be decreasing, that each movement shall be shorter than the immediate preceding one, for then the weight will very soon arrive at its proper position of equilibrium. It sometimes happens that the oscillations *increase* in amplitude and this will cause the engine to "race," a well known phenomenon. Fig. 2 is a true representation of part of a spiral line of oscillation taken from an inertia governor making 240 revolutions per minute. The outer circle corresponds to the initial position of the eccentric and the time of motion from there to the first crossing of the inner circle at O is about one-third of a second, which shows the remarkable quickness of action of this governor. As half of the load was suddenly thrown off, it is almost certain that the inertia weight was immediately put into action by the sudden impulse, but the diagram does not give any evidence in regard to this.

I have in my last article mentioned the small periodic fluctuations in speed due to the varying rotative effect of the force exerted on the crank and have shown "mathematically" that the vibration of the inertia weight, due to the periodic acceleration and retardation of speed, must be very slight. By carefully examining several circles described by the eccentric, I have found these circles to be slightly distorted, showing a radial motion of the eccentric of $\frac{1}{64}$ to $\frac{3}{64}$ inch during each revolution; which is rather less than would be expected. It will, no doubt, be more in slow running engines unless the moment of inertia of fly-wheel is greatly increased, but it can have no prejudicial effect on the regulation.

It is a well-known fact that nearly all centrifugal governors will allow the speed of the engine to vary more or less, the speed will be somewhat slower when the engine is fully loaded than when running light. This is true of fly-ball governors with vertical spindles and of shaft governors also. In Watt's governor, this variation is due to the different attitudes of the balls, but in shaft governors it is due to a deficiency in initial tension of the springs. The initial tension or deflection may, of course, be increased so as to make the speed under full load just the same as when running light, but then the governor will certainly be racing. This is generally accounted for by the fact that the resistance of the spring must be increasing when the weight moves out from the center, otherwise it will move too far. This is a simple explanation, but not entirely satisfactory. The fact is, that it is not the resistance of the spring, but friction which keeps the oscillation within proper limits. The spring may offer an increasing resistance but it cannot destroy the energy of motion, it simply stores it for a moment and then gives it out in the opposite direction. Why is it then that the spring cannot have full theoretic tension in a centrifugal governor? This can best be explained by a graphical representation. In Fig. 3, let the position of equilibrium where the centrifugal weight will finally come to rest be at O, and supppose it to be oscillating on both sides of this position between A and B, and let friction be represented by ordinates to the parallel line C D; then evidently motion cannot commence at A before the centrifugal force has increased sufficiently to overcome the resistance of friction, and after motion has commenced, centrifugal forces will still be increasing till the position O is reached, and after this position is passed it will be decreasing. At the extreme positions, as at A and B, we have mean speed, and the increase in centrifugal force or unbalanced centrifugal force during motion from A to B may be represented by ordinates to the curve C E D. The whole energy of the impelling force is then represented by area A E B; of this the energy represented by the area A C D B is consumed by friction, but the remaining energy represented by area C E D will carry the weight beyond the position B; the oscillation will be increasing and the governor will race. In this case the spring is supposed to have full theoretic tension. Now let us see what difference it will make if the initial tension of the spring is reduced. O is the position of equilibrium where the weight will finally come to rest, and if we suppose it to move from this position either way it will meet an increasing resistance due to an excess or deficiency in spring tension, and this resistance

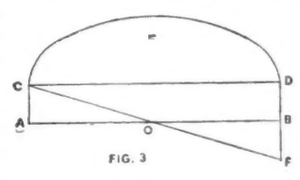

FIG. 3

may be represented by a slanting line C F. After the motion has been arrested by the increasing resistance of the spring at A or B, a reaction will take place in the opposite direction, which is sufficient to overcome all the friction, or part of it, at the *commencement* of each movement, thus allowing the remaining energy of motion to be consumed gradually by friction before the weight has arrived at the opposite extreme position. The oscillation will then be decreasing and the weight will soon come to rest at its position of equilibrium at O. This explanation is rather abbreviated and the reader may find it hard to understand the somewhat incomplete analysis, but it should not appear difficult to those who have studied the principles of oscillation. It should be undersood that only a small amount of friction is needed to keep the motion within proper limits. We may compare the oscillation of a centrifugal governor with that of a pendulum, but it would not be a satisfactory comparison and it might be misleading, for the action of gravity on a pendulum is radically different from the action of centrifugal force on a governor weight. The only force in a centrifugal governor which corresponds to the action of gravity on a pendulum is the reciprocating force represented by the slanting line C F. Such reciprocating force is necessary for stability in any governor. It cannot be obtained in the ordinary centrifugal governor without reducing the initial tension of the spring, but in an inertia governor it is obtained directly from the inertia weight, for it can easily be seen from Fig. 3 that if A represents the inner and B the outer position of the centrifugal weight, the acceleration and retardation of rotative speed will be greatest at these two points, and that the force or reaction of the inertia weight being proportional to the acceleration and retardation will be greatest there. It is, therefore, not necessary to reduce the initial tension of the spring in an inertia governor; it may be adjusted for perfect isochronism, and "over adjustment" does not destroy the action of an inertia governor, it will in any case be perfectly stable and there will be no tendency to race if it is properly desigued.

If we reduce the moment of inertia of the fly wheel; that is, if we use a smaller or lighter fly-wheel, the reciprocating force due to the inertia weight will be increased proportionally; and very small and light fly-wheels are therefore admissable when the regulation is effected by an inertia governor.

This is another advantage of the inertia governor, for it is a well-known fact that pretty heavy wheels are needed to obtain close regulation from the ordinary centrifugal governor, as can also be demonstrated by analytical methods.

We have made some experiments to determine how light a fly-wheel could be used with an inertia governor, and I can give some information in regard to this which I think will make interesting reading for those who believe that a heavy fly-wheel is necessary, no matter what sort of governor is used, and who think that the accelerating and retarding efforts during each stroke of the engine is what does the mischief when light fly-wheels are used.

A tandem compound engine, 14 and 28 inch cylinders, 20 inch stroke, 180 revolutions, 125 pound steam was selected for the test. It was direct connected to a 200 k-w. dynamo whose armature weighed 5,000 pounds, and the mean diameter was 39 inches, being unusually small for the power. The engine had two crank disks 42 inches in diameter, weighing 900 pounds each. The governor wheel was 72 inches in diameter, 15¼ inch face, rim 1½ inch thick, weighing 1,400 pounds. The combined moment of inertia of revolving parts was equivalent to the moment of inertia of a rim 72 inches in diameter weighing 3,200 pounds. From these data we can calculate approximately the deviation from mean speed or the co-efficient of fluctuation during each stroke of the engine; it is about 3 per cent. of mean speed. The electromotive force was 500 volts, and when the engine was about fully loaded the hand of the volt meter appeared to oscillate slightly in sympathy with the engine, showing a deviation of little over one volt, say one-quarter of one per cent. of the whole electromotive force. Belted to the engine shaft was a very sensitive tachometer, and the hand of this instrument showed a slight continuous oscillation, but it was a varying periodic oscillation as should be expected when the natural or free oscillation of the instrument nearly coincides with the stroke of the engine.

This motion of the tachometer hand was probably due to the small deviations of speed, but the actual extent of these could not be estimated on account of the exaggerated free oscillation of the tachometer. There is, however, no reason to doubt that the actual fluctuation in speed for each stroke of the engine was 3 per cent. as calculated, but what was the practical effect? The volt meter was a first-class instrument and would certainly not show anything less than the actual fluctuation in the current, and it showed a variation of one-quarter of one per cent. in electromotive force. Would this show any flickering of the lights? The electrician says positively that it will not, and he ought to know.

Now this engine was for railroad work, and the governor wheel could, no doubt, have been reduced to its smallest possible size without any injurious effect on the current. It is claimed that for smooth running the periodic fluctuation should not amount to more than one per cent. of mean speed, and according to a formula given by well known steam engine builders and supposed to agree with good practice the equivalent weight of fly-wheel rim for this engine should be about 10,300 pounds, while Rankine says that the co-efficient of fluctuation of speed should be about $\frac{1}{33}$ for ordinary machinery and $\frac{1}{60}$ for machinery for fine purposes: yet here we have an engine working satisfactorily for incandescent lighting with a co-efficient of fluctuation of $\frac{1}{83}$ which in all probability could be increased considerably without detriment to the lights.

We had a smaller engine making 150 revolutions per minute with a small and light fly-wheel, the hand of the tachometer did not show any fluctuation of speed, and the regulation seemed perfect in every respect. Are we to believe that the speed of these engines would not be uniform enough for a grist mill or an air compressor, while it was perfectly satisfactory for incandescent lights?

We have built engines with fly-wheels of various sizes, weights and numbers, and only in one single case has there been a slight flickering of the lights, and in that case there was a large fly-wheel and two large driving pulleys on the shaft. To remedy the trouble another fly-wheel was substituted, being twice as heavy as the first one, and when I last heard, it was undecided whether it made any difference in the lights. Now the dynamos were in this case belted to the engine, and I have no doubt that the trouble was due to the belting and not to the engine.

* * *

THE FIRST PRINCIPLES OF MECHANICS.—3.

LESTER G. FRENCH.

CENTER OF GRAVITY.

In the last number an explanation was given of the meaning of the term "center of gravity." In this number we have to consider some of the principles involved in finding this point, together with a few of their applications.

A body suspended at its center of gravity will balance in whatever position it may be placed. For this reason the center of gravity is sometimes defined as that point about which a body will balance, in any position. Any *homogeneous* body will balance about its center of magnitude; that is, about its central point. Hence, in the case of *regular* geometrical figures, the center of gravity is readily determined, as the center of magnitude can usually be found by inspection.

CENTER OF GRAVITY OF GEOMETRICAL FIGURES.

The center of gravity of a line is at its middle point; of a circle at its center; of a rectangle at the intersection of two lines joining the opposite corners; of a sphere or ball, at its center; of a prism and cylinder, at the middle point of a line joining the centers of gravity of the two ends. To illustrate the last two cases, the center of gravity of a bar, of any homogeneous material, four feet long, two inches wide and one inch thick, lies at a point two feet from one end, one inch from the edge and one-half inch from one side; and of a round bar of the same length, at a point on its axis two feet from one end.

The center of gravity of a triangle lies at the intersection of two lines drawn from the vertex (point) of any two angles to the middle of the opposite sides (Fig. 7). This point may also be found by drawing one of the lines, as A B, and laying off two-thirds of its length from the vertex. Thus, the center of gravity G in the figure is at a distance A G from A, equal to two-thirds of the length of the line A B, and the same proportion holds with the lines drawn from the other two vertices.

The center of gravity of a parallelogram is at the intersection of its diagonals, as A B and C D in Fig. 8. A parallelogram is a figure having four sides, the opposite ones being equal and parallel.

The center of gravity of a cone or of a pyramid is on a line drawn from the vertex to the center of gravity of the base, and at

a distance from the vertex equal to three-fourths of the length of the line.

A help in finding the center of gravity of a plane figure is the fact, that, if it has an axis of symmetry, the center of gravity will lie at some point upon this axis, and if it has two such axes, the center of gravity will lie at their point of intersection.

A plane figure is here understood to be a flat, material body, that is very thin compared with its extent or area, such as figures cut out of paper or sheet metal. Strictly speaking, a plane figure has extent but no thickness.

An axis of symmetry is a line so drawn across a figure that it divides the latter into two parts, one of which would exactly coincide with the other, if the figure were folded over along this line. Thus, if the regular pentagon in Fig. 9 were folded about the line A O, the parts A B D and A F E would exactly coincide; and if it were folded about B N, parts B A F and B D E would coincide. Hence, A O and B N are axes of symmetry, and the center of gravity of the figure lies at their intersection, or at G.

CENTER OF GRAVITY OF TWO OR MORE BODIES.

In Fig. 10 let the point G be the position of the center of gravity of the two bodies w and W. It must be so situated that they will balance about it, if rigidly connected. The turning effect exerted by each body about the point G is as though the weight of each were concentrated at its own center of gravity, and acted downward at that point, as indicated by the arrows. Moreover, as will appear when the subjects of moments and levers have been studied, if w and W are to balance, the ratio of the distances D′ and D must be such that, calling w and W the weights of the two bodies, the proportion $w : D = W : D'$ will exist. Thus, if $w = 50$ pounds, W 250 pounds and D′ 25 inches, then $50 : D = 250 : 25$, and $D = \frac{25 \times 50}{250} = 5$ inches.

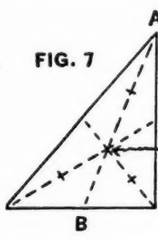

FIG. 7

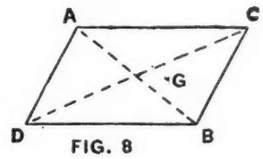

FIG. 8

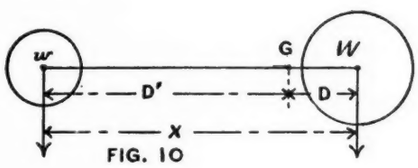

FIG. 10

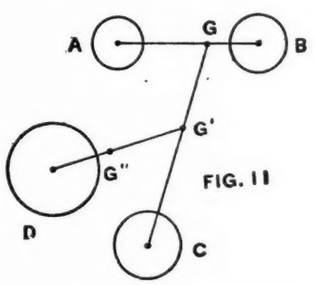

FIG. 11

The center of gravity lies upon a line connecting the center of gravity of each weight, and its distance D′ from the smaller weight is expressed by the formula

$$D' = \frac{W x}{W + w}, \quad (7)$$

where x = the distance between the centers of gravity of the weights,

W = the weight of the larger body,

and w = the weight of the smaller body.

Stated as a rule, *to find the distance D, multiply the larger weight by the distance between the centers of gravity of the two weights, and divide by the sum of the weights.*

Example 1.—Using the same numerical values as above, if W = 250 pounds, w 50 pounds, and $x = 30$ inches, how far is the center of gravity from the center of the *larger* weight?

$$\text{From (7), } D' = \frac{250 \times 30}{250 + 50} = 25 \text{ inches,}$$

$$\text{and } 30 - 25 = 5 \text{ inches} = D.$$

This same method may be applied successively for obtaining the center of gravity of a system of more than two bodies. Suppose, for example, that there are three bodies. Find the position of the center of gravity of any two, as in the last example, and call it G. The weights of these two bodies may now be assumed to be concentrated at G and treated as though there were one weight situated at that point. Draw a line from G to the center of gravity of the third body, and proceed as before, finding the position of the center of gravity of this body and of the weight concentrated at G. If there were four bodies, it would simply be necessary to continue the operation, assuming the weights of the first three to be concentrated at the last center of gravity found. The process will be more apparent by the solution of an example.

Example 2.—In Fig. 11, let the weight A weigh 12 pounds, B 14 pounds, C 22 pounds, and D 50 pounds, and the distance between the centers of A and B be 39 inches. Then the center of gravity G of A and B is at a distance from A equal to $\frac{14 \times 39}{14 + 12} = 21$ inches (Formula 7), and at this point their combined weight, or 26 pounds, may be assumed to be concentrated. Now connect G with weight C, and suppose the distance G C to be found to be 60 inches. The distance of the new center of gravity G′ from the smaller body, which is in this case C, is equal to $\frac{26 \times 60}{26 + 22} = 32\frac{1}{2}$ inches. At this point it may be assumed that the weight of A, B and C, or 48 pounds, is concentrated. Finally, connecting G′ with the center of gravity of D, we have, if we suppose D G′ = 49 inches, the distance from G′, where the smaller weight is situated, $= \frac{50 \times 49}{50 + 48} = 25$ inches, and G″ is the center of gravity of the whole system.

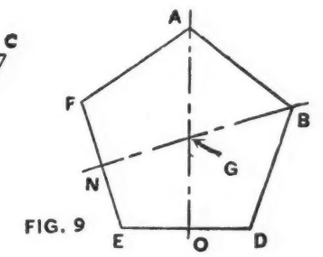

FIG. 9

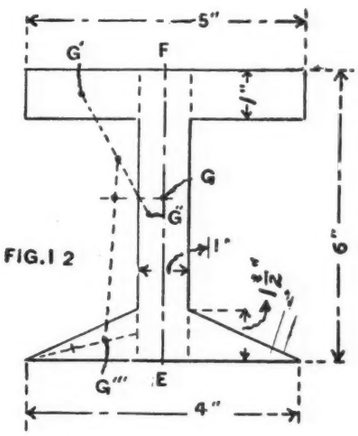

FIG. 12

The same method can be used to find the center of gravity of irregular plane figures, the only difference in the process being that in this case the figure should be divided into elementary sections, such as triangles, squares, etc., the center of gravity of each of which can be easily determined, and then the center of gravity of the whole found by taking the *areas* of these sections instead of their weights. In Fig. 12, we know that the center of gravity must lie on the axis of symmetry F E; hence it is only necessary to find how far up or down the point comes. This can be done by considering that part of the figure on one side of the axis F E, simply. The small letters indicate the center of gravity of each section, and G′ the center of the entire figure.

CENTER OF GRAVITY BY TRIAL.

If a body be suspended from a point, or otherwise supported so that it is free to vibrate and find its "own center," its center of gravity will place itself in the lowest possible position. If a piece of sheet metal be freely suspended from a nail, for example, the center of gravity will lie in a vertical direction beneath the point of support. This fact may be taken advantage of in order to find the center of gravity of a flat plate by trial. Suspend it from some point, as in Fig. 13, and from the same point hang the plumb-bob B′. When both have come to rest, hold the string against the plate, and, using it as a guide, draw a line, A B across the plate. As the center of gravity falls vertically below the point of support, it must lie at some point in this line. Next, suspend the plate from some other convenient point (Fig. 14), and repeat the operation, drawing the line C D. The center of gravity must

lie in this line, also, and hence its location is at the intersection G of lines A B and C D, since this is the only point common to them both. Furthermore, from however many points the plate might be suspended, the plumb-line would pass through the point G. Two suspensions determine the point, however, and are all that are required.

APPLICATIONS OF PRINCIPLES.

(*a*) A body is said to be in equilibrium when it balances, or has no tendency to rotate or overturn. When acted upon solely by the force of gravity, the only conditions necessary for the equilibrium of a body is that a vertical line through the center of gravity shall pass through the point or surface which supports it. Thus, in Fig. 14, the plate is in equilibrium as drawn, and theoretically it would also be in equilibrium if it were turned half way around, so that the center of gravity came directly above the point of support. In the former case, however, the equilibrium is said to be stable, while in the latter it is unstable. *Stable equilibrium exists where, on moving the body, the center of gravity ascends; and unstable equilibrium when it descends.* By swinging the plate of Fig. 14 about its point of support, the center of gravity would rise, and with the position of the plate reversed, if it were moved either way, the center of gravity would fall.

The case of bodies resting on a horizontal base is illustrated in Fig. 15. A leaning body, a chimney, for example, would remain in equilibrium so long as a vertical through its center of gravity passed within the base, as is the case here with the center of gravity at G. Moreover, the equilibrium would be stable, because the chimney, in overturning, would act as though pivoted at O, which is at the right of G, and therefore the center of gravity would have to ascend, slightly, along arc G A. Should the center of gravity be located at G′, the equilibrium would be unstable, because, at the moment of overturning, G′ would begin to *descend* along the arc G′ B. With the center of gravity at G″, the vertical falls without the base, and the chimney would overturn.

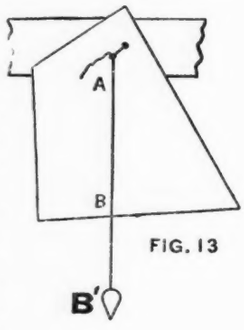

FIG. 13

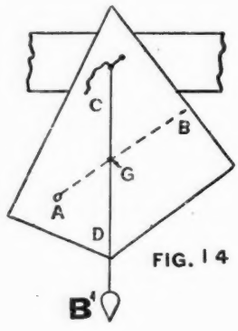

FIG. 14

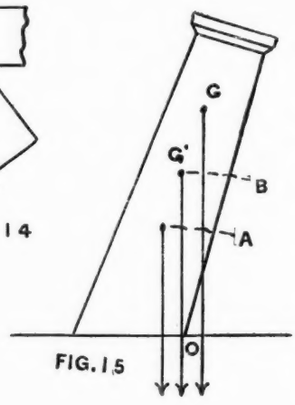

FIG. 15

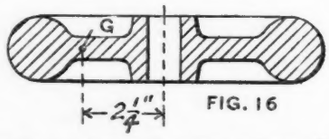

FIG. 16

Equilibrium is said to be *neutral* when, upon moving a body, its center of gravity neither ascends nor descends. Examples: A flat plate suspended at its center of gravity; a cylinder, cone or sphere rolling upon a horizontal surface.

(*b*) A useful application is found in one of the "Theorems of Pappus," which is that the volume of any solid which can be generated by the revolution of a surface about an axis is equal to the area of the surface by the circumference described by its center of gravity.

Example 3.— Let it be required to find the weight of the cast-iron, webbed hand-wheel shown in section in Fig. 16. It is evident that, if a plane figure were cut out of the shape of one-half of the section of the wheel, or of that part on the left of the axis, and that if this figure were rotated once about the axis, it would describe a volume equal to and like that of the wheel. Any solid which can be formed in this way is called a solid of revolution.

Applying the theorem, let it be supposed that we have found by the principles of mensuration that the area of the left-hand section C is 2.4 square inches, and by one of the foregoing methods that its center of gravity is at a point G, 2¼ inches from the axis.

Circumference of circle of 2¼ inch radius = 14.14 inches.

Volume of wheel = 14.14 × 2.4 = 33.94 cubic inches.

Weight of wheel = 33.94 × .26 = 8.82 pounds, assuming the weight of one cubic inch of cast iron to be .26 of a pound.

This method can be advantageously used in finding the weight or volume of circular rings of any form, or of any other solid of revolution.

EXERCISE 3.

1. A rectangular tank contains 200 cubic feet of water, the level of which is 6 feet above the bottom of the tank. This water when pumped into another rectangular tank stands 4 feet above its bottom. The bottom of the second tank is 16 feet above the bottom of the first. Find the work done in pumping the water. (From Low's Mechanics).

NOTE.—Find the distance through which the center of gravity of the water is raised.

2. Where is the center of gravity of two weights of 8 and 10 pounds, respectively, connected by a rod 2 feet long. The weight of the rod is neglected.

3. A rod of uniform diameter 40 inches long and weighing 6 pounds has a weight of 1½ pounds at one end and of ¾ of a pound at a distance of 4 inches from the other end. Where will it balance?

4. Assuming the dimensions given in Fig. 12, find the position of the center of gravity of the figure.

ANSWERS TO EXERCISE 2.

1. (*a*) .16⅔. (*b*) 3.5 pounds.

2. From formula 6, $.35 = \frac{35}{100} = \frac{h}{b}$. Referring to Fig. 5, the h and b sides of the triangle must be in the ratio of 35 to 100, or of 7 to 20.

3. Work done against gravity = 500 foot pounds. Length of base = $\sqrt{10^2 - .5^2} = 9.987$ feet; work against friction = 9.987 × .14 × 1000. Answer, 1898 + foot pounds.

4. (*a*) From formula 6, $.42 = \frac{1}{b}$, or $b = 2.381$, nearly, from which we get length of plane = 2.58 + feet, or 30.96 + inches. (*b*) 8.4 inches.

* * *

MESSRS. Coleman Sellers, E. D., Consulting Engineer, and Horace W. Sellers, Architect and Engineer, have removed to rooms 537-539, Philadelphia Bourse.

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USELESS TUBES IN BOILERS.

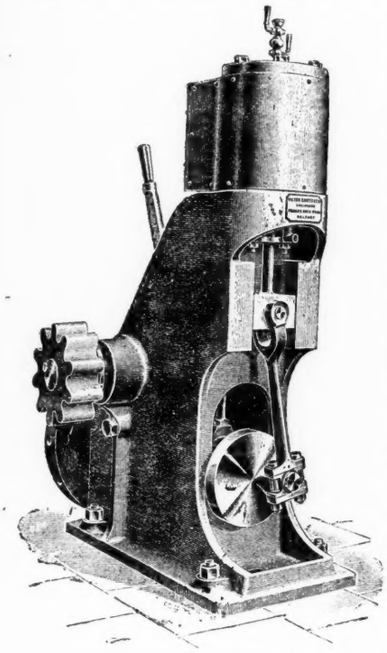
The Locomotive, in a recent issue, has an article on this subject, which calls attention to the mania for a large number of tubes in a boiler, and shows conclusively that the extra heating surface obtained by crowding tubes is not only inefficient but positively detrimental. It says:

"In the early history of the horizontal tubular boiler, the opinion prevailed that the more tubes that were crowded into a boiler the greater the efficiency would be. It was not uncommon to find the lower half of a boiler literally packed with 2½-inch tubes. They were put down as near the bottom and the side sheets as the flanging of the tube-head would allow. They were arranged in the boiler on what is known as the "staggered" plan; that is, instead of being placed vertically one over another, they were so arranged that the tubes of one row were placed over the spaces of the row next below, and there were consequently no unobstructed spaces through which the water could circulate. But this was not the greatest difficulty. It is well known that the waters used in boilers carry more or less impurities in suspension —mechanical or chemical—and that these are deposited in the process of evaporation. The deposit so formed may consist of the carbonates or sulphates of lime or magnesia, or of argillaceous matter, or of mud, It settles upon the bottom and the tubes of the boilers, and if the cleaning is not frequent and careful, there will be formed, on the bottom and among the tubes, a very hard scale, which cannot be removed without taking out the tubes. When this condition of things has come about, the efficiency of the boiler is greatly reduced. The heating surface being covered, more or less, by a substance which is a non-conductor of heat, the heat, in passing over it, is not taken up, and so passes on and is lost."

FOREIGN NOTES OF REAL INTEREST.

BARRING ENGINE.

The barring, or starting engine shown (from *Engineering*, London) is the product of Messrs. Victor Coates & Co., Ltd., of Belfast, and the design is so compact that it is worth noting. The general lines closely resemble a drop hammer, and being so much self-contained does not require much foundation. It can be placed either side of the fly-wheel and in either position will wind itself out of gear as soon as the main engines are started. This result is obtained by the usual worm-wheel arrangement. The crank-shaft, worm and disc are of one solid steel forging, the rest of the engine being of equally rigid construction.



DISC-CUTTING MACHINE.

We illustrate a disc-cutting machine, for cutting out discs from plates. The machine comprises two standards, to which are bolted a cross-slide carrying four drill-heads, each having a balanced steel spindle 7 inches in diameter, running in parallel bronze bearings. Each drill-head has independent adjustment along the cross-slide, and each spindle has independent vertical adjustment of 6 inches (by hand or power) by means of a three-speed cone and screw, and is fitted with a quick withdrawing motion operated by hand.

To each spindle is bolted a cutter arm, fitted with two tool-boxes (one having independent vertical adjustment), one on each side of the spindle. These boxes are adjustable to and from the center of the spindle, so as to cut out circles from 9 inches to 30 inches in diameter in plates up to 1 inch thick. The spindles are hollow, and down the center is a jack screw, which engages with a clamping plate for holding the plate which is being operated upon. The table extends out in front, and is firmly keyed and bolted to the uprights, and is also supported by means of four standards. The distance between the centers of the spindles is variable to suit the various sizes of discs, the maximum distance being 42 inches. The machine is driven by a four-speed cone, 6 inches wide and 30 inches in diameter at the top speed. The motion is conveyed through strong spur gear and bronze worms (running in oil wells) and a steel worm-wheel on the spindle, each spindle being fitted with independent stop motion by means of a clutch. This machine is designed for cutting out eight plates, 30 inches in diameter and 1 inch thick per hour, or 12 plates 24 inches in diameter and 1 inch thick per hour, and weighs 13½ tons. The makers are Messrs. Ward & Haggas, of Eastwood Tool Works, Keighley, Yorkshire. —*Engineering, London.*

THE FIRST CASTING OF IRON.

Cast iron did not come into commercial use before 1700, when Abraham Darby, an intelligent mechanic, who had taken some Dutch workmen to establish a brass foundry in Bristol, England, conceived the idea that iron might be substituted for brass. This, his workmen did not succeed in doing, being probably too much prejudiced in favor of the metal with which they were best acquainted. A Welsh shepherd boy, John Thomas, had some time previous to that been received by Abraham Darby into his workshop on the recommendation of a distant relative. While looking on during the experiments of the Dutch workmen, he said to Darby that he thought he "saw where they had missed it." He begged to be allowed to try, and he and Darby remained alone in the workshop all night, struggling with the refractory metal and imperfect molds. The hours passed on and daylight appeared, but neither would leave his task. Just as the morning dawned they succeeded in casting an iron pot complete. The boy entered into an agreement with Darby to serve him and keep the secret. Although enticed by offers of higher wages to leave his master, he continued faithful, and from 1709 to 1828 the family of Thomas were the confidential and valued agents of the descendants of Abraham Darby. For more than a hundred years after that night, in which Thomas and his master succeeded in making an iron casting in a mold of fine sand contained in frames and with air holes, the same process was practised and kept secret at Coalbrook Dale with plugged keyholes and barred doors.—*The Canadian Engineer.*

JOINTLESS CYCLE RIM.

Engineering, of London, in a recent issue, devotes considerable space to the illustrations and description of a new process for making jointless rims for bicycles and similar wheels. These are first pressed into the shape of a shallow pan, the center then cut out and the rim finally shaped by spinning, making a rim of U section without a joint. As hollow rims are desired, another rim is made to close in the top of the U section and these are carefully soldered together, so that while the rims are jointless. so far as their circumference is concerned, there is a joint between the two sections of the rim.

As this is soldered instead of brazed, however, the rim is not weakened by heating as in the case of the brazed rim. These rims are subjected to very severe tests, such as supporting without set a 250 pound man, with only two points of support, also by throwing rims from a considerable height, after which they are tested in the lathe.

The presses used for the first operation, *i, e.*, dishing the blanks, are heavy affairs, made by Messrs. Taylor & Challen, of Birmingham, England, and weighs 35 tons, standing about 15 feet high, judging from the engraving. The presses are of the "camless" type, the inner or forming slide being moved by crank and connecting rod. These are very interesting mechanically and show that steel rims are still in demand on the other side, while in America they have practically been abandoned for the wooden rim.

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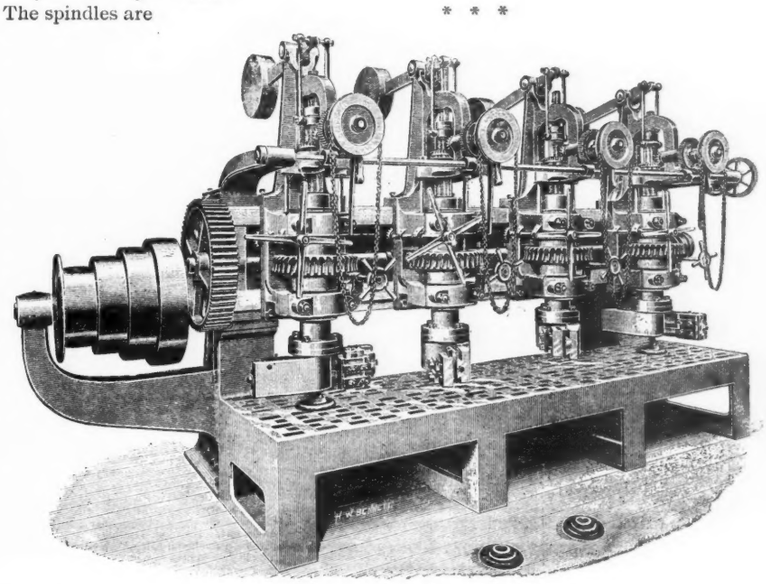


DISC-CUTTING MACHINE.

TO TEST SHELLAC, dissolve it in absolute alcohol, which will dissolve shellac and leave impurities. Absolute alcohol should indicate 1000 upon an alcoholmeter. Pure alcohol will all burn away; that which has water in it will leave most of the water behind.

TWENTY-ONE INCH DRILL.

This is one of the latest productions of Mr. J. E. Snyder, Worcester, Mass., whose drill presses are to be found in all parts of the country. It is quite a heavy machine, has back gears, power feed, quick return and automatic stop, and has a combined wheel and lever feed. Table adjusts with crank shown, in connection with worm and worm gear, and can be swung clear around the column. Wheel feed is by worm gearing and steel rack and

pinion. Back gearing is controlled by lever and very readily operated. The spindle is 1½ inches diameter and has a movement of 10 inches, and is 10⅝ inches from post. Table is 18½ inches in diameter and has a vertical movement of 15½ inches. Greatest distance from spindle to base is 43½ inches, and from spindle to table 25 inches. Hole is No. 3 Morse taper. It requires a floor space of 22x52 inches, and is 98 inches in height and weighs 800 pounds.

* * *

"STATES" MILLINC MACHINE.

Owing to a series of unfortunate occurrences we were unable to present detailed drawings of the milling machine of the States Machine Co., Hartford, Conn., in our last issue; and as it contains several features which are not generally known we give them in this number. The main or milling spindle contains inside it, a

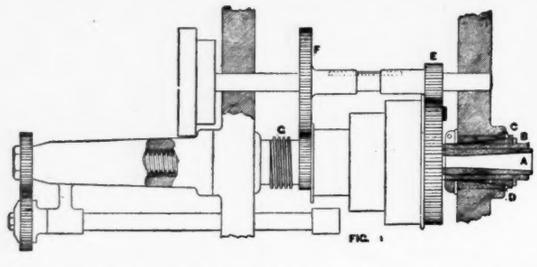


FIG. 1

second and boring spindle A, which is splined to it and revolves with and inside of it when used for milling. There is a taper bearing as shown at C, which insures the spindle remaining in the original center line, regardless of wear. The rear bearing is practically straight, as most of the wear comes on the front bearing. The broken section at the left of the spindle shows the construction of the boring spindle, which is fed into the work by the screw shown. The worm G drives the boring feed from the main spindle through changeable gears to the screw which drives the cutter into the work.

The use of the machine as a small boring mill is shown in Fig. 2, where the cutter bar C is driven by the interior spindle and is supported by the pendant, which insures accurate boring. Fig. 3 shows a drill pad in the pendant, with various sized holes—the drill being shown coming through one of them. This ensures more accurate drilling being done than is possible without this support at the point of entering work.

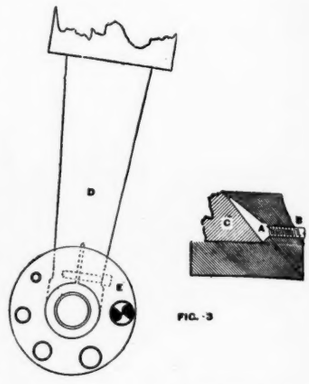


FIG. 3

The back gears lie inside of the frame, sliding separately on a feather. The back gear spindle carries the platen feed, which can be thrown in or out by sliding the gear in or out of mesh, without interfering with the back gear connections. The small detail in Fig. 3 shows the method used in all gibs on this machine. They are all wedge shaped and held to place by set-screws, so that there is a full bearing instead of only on the points of the set-screws, as in many machines.

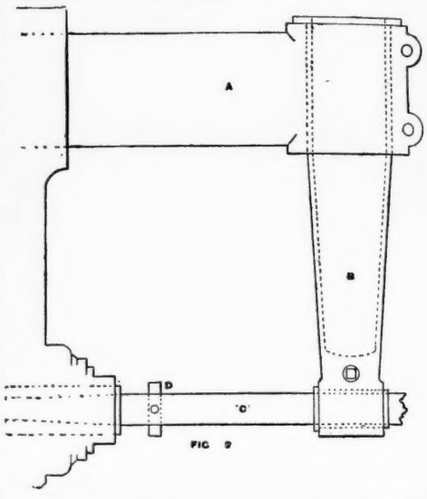


FIG 2

* * *

A NOVEL CALIPER ADJUSTMENT.

The engraving shows a mode of obtaining fine adjustment of calipers, devised by Mr. A. Munch, of 653 East 5th street, St. Paul, Minn. It is simply an addition to the ordinary plain caliper, of the adjusting screw D, the arm E and the thumb-nut G.

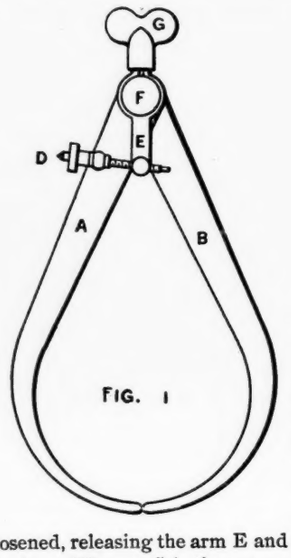
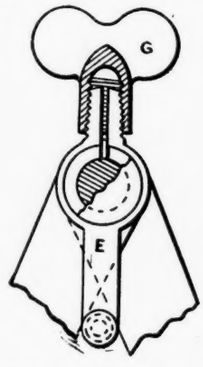


FIG. 1



The arm E is held by a bevel headed rivet, and being split on the top can be tightened by the thumb-nut G so as to form a rigid nut for the adjusting of the leg A. In use the thumb-nut is loosened, releasing the arm E and the caliper set to the approximate size. The nut G is then screwed down and the final adjustment made by screw D. The adjusting screw can be readily swung out of the way in case it is not required.

* * *

Don't wait till you can save 25 per cent. in cost of production; even 5 per cent. is not to be neglected.

A MODERN FOUNDRY PLANT.

Foundries are too apt to be neglected when the plant is being improved, but this was not the case with the Henry R. Worthington Hydraulic Works. This was established in Brooklyn in 1845, but owing to the limited space available it became necessary to use the ground occupied by the foundry for an addition to the machine shop, and the foundry was moved to Elizabethport four years ago.

The new foundry plant occupies over ten acres and has ample dock and railroad facilities, their own steam lighter plying between the foundry and the Brooklyn plant. The foundry was erected under the supervision of their own engineer, and is very complete and modern in every way, turning out an average of sixty tons of iron castings and three tons of brass castings per day.

The buildings comprise the green sand foundry 340 feet long by 120 feet wide; the loam foundry, 240 feet long by 90 feet wide; the brass foundry, 110 feet long by 80 feet wide; core shop, 100 feet square; pattern shop, a two-story building 80 by 80 feet with pattern-shop storage building 300 by 80 feet, including a number of smaller pattern storage buildings for special patterns. There is also a storehouse for finished castings, 200 feet long by 43 feet wide, together with engine and boiler house, chipping shops, storehouses for sand and coke, etc.

MAIN FOUNDRY—SHOWING CRANES AND SAND CAR.

The power plant consists of a 120 HP. Ball & Wood engine, and a 40 HP. vertical engine, and 45 and 60 Kilo-Watt dynamos. There are also two Worthington air compressors, one of which is a compound condensing type; one Underwriter fire pump of 1,000 gallons per minute capacity, a pressure pump, an Independent condenser, besides a deep well pump and two boiler-feed pumps, all of the Worthington manufacture.

The steam, after being used by all these machines, is exhausted into the condenser, to which is attached a Worthington self-cooling tower, by which the same water is used over again for condensing purposes. More will be heard of this later.

In the iron foundries there are three cupolas, with an aggregate melting capacity of 30 tons per hour. Test bars from each heat are carefully tested, many of the castings being made of semi-steel, which possess a close-grained and very high tensile strength particularly suitable for hydraulic machinery.

The main feature of the foundry is its moulding machines, fifteen in all, of different sizes, varying from 32×32 inches down to 16×16 inches. The majority of these are pneumatic, the others being Tabor, and of their own make. Some of these machines can turn out over 250 flasks per day, the work being of a very superior quality. Each machine has its own pneumatic crane, and the speed with which it handles flasks and takes care of the molten iron must be seen to be appreciated.

A HEAVY MOLDING MACHINE WITH HOIST.

CUPOLA AND HEAVY CRANE.

These buildings are all connected with a system of standard and narrow-gauge tracks, to facilitate the quick handling of material. The buildings are equipped with electric power and pneumatic cranes, to an extent that is unusual in even the best equipped foundries.

There is one 30-ton, five 15-ton, three 8-ton, two 5-ton, six 3-ton, and fifteen cranes of 2 tons capacity and under.

The moulding machines with their pneumatic cranes represent about 7 per cent. of the cost of the patterns.

The brass foundry contains twelve furnaces, and has two pneumatic traveling cranes to lift crucibles from furnace and pour the molten brass in moulds throughout the length of the shop. All

standard work is done on the moulding machines similar to the others described.

The castings are conveyed from the foundry dock by the company's steam lighter, which has a capacity for lifting a twenty-five ton piece, and carrying 250 tons. A special lighter transports heavier work to the works in Brooklyn, which will be described in a later issue.

* * *

PLAIN TALKS ON MECHANICAL DRAWING.—(1).

LOUIS ROUILLION.

This course in mechanical drawing is designed to meet the wants of the machinist or pattern-maker who desires a better understanding of the drawings that daily pass through his hands. The course will consist of about forty sheets, four of which will, as a rule, be presented each month. The first sheets will deal with the elementary principles, including the proper use of instruments, laying out of work, relation of views, methods of projection, etc. A series of sheets will be devoted to the development of surfaces, or the laying out of patterns. Familiar objects have been chosen for this purpose, and the supposed difficult subject of intersections will thus be simply and easily acquired. The course leads up gradually and logically to a complete set of working drawings of a lathe, and any one conscientiously following the course from month to month should have no difficulty in reading complicated drawings and clearly understanding the principles involved in the making of them.

The course may be followed in one of three ways. First, the student may make the drawings shown in each issue. These when finished will make a complete set and fulfill the design of the course. It is recommended, however, that the student preferably follow the course given in the exercises, which is a parallel independent course. To do this intelligently the regular course should first be read carefully, and with the knowledge thus gained the exercises should be drawn. Or thirdly, if a student has sufficient time, it would be well to make the drawings of both courses.

Each word of the explanation of the sheets should be carefully read, or else useful rules may be overlooked.

* LIST OF MATERIALS REQUIRED.

Drawing board, about 16×23 inches.
Compasses, 5½-inch, with needle point, pen, pencil and lengthening bar.
Drawing pen, 4½-inch.
T-square, 24-inch blade.
45° triangle, 9-inch.
30°–60° triangle, 11-inch.
Scroll.
HH lead pencil.

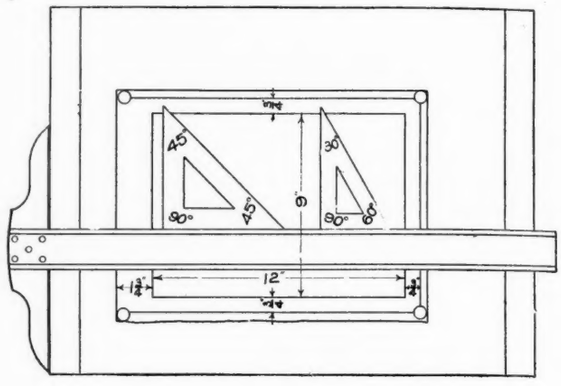


FIGURE 1.

12 inch boxwood scale, flat graduated to $\frac{1}{16}$ inch the entire length.
Bottle of liquid India ink.
One-half dozen thumb tacks.
Pencil and ink eraser.
Drawing paper, preferably light brown; the brand known as "Duplex" is a desirable paper and comes in sheets 22×30 inches, that make four exercise sheets.

USE OF MATERIALS.

PAPER.—Cut the paper into sheets about 11×15 inches. Tack a sheet upon the drawing board with thumb-tacks as shown in diagram, placing the sheet well over towards the left-hand side of the board. This permits of greater firmness in the use of T-square and triangles.

T-SQUARE.—The head of the T-square is always kept against the left-hand edge of the board, and its upper edge is used in drawing all horizontal lines and for resting the triangles upon.

TRIANGLES.—The triangles are used in drawing all straight lines other than horizontal ones. They are rested upon the upper edge of the T-square, and thus afford means of drawing vertical lines and lines at 30°, 45° and 60°. By placing one tri-

A CORNER IN FOUNDRY—HEAVY WORK. SEE PAGE 115. BRASS FOUNDRY—AIR HOIST AND TRAVELING CRANE.

angle upon the other, angles of 15° and 75° may be obtained. (Fig. 2.)

PENCIL.—For convenience, the pencil should be sharpened at both ends. One end should be brought down to a flat, chisel-like edge, and used for drawing straight lines. The opposite end should be sharpened to a round point, and used for putting in letters, figures, arrow-heads, and other free-hand work.

COMPASSES.—The compasses are supplied with detachable points, pen and pencil, and are used for drawing circles and arcs of circles. By placing points in both legs they may be used as dividers for stepping off distances.

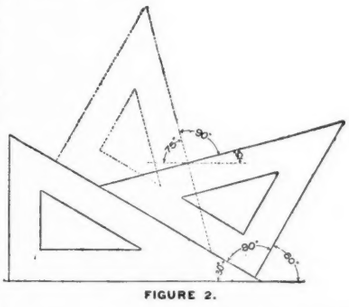


FIGURE 2.

DRAWING PEN.—The pen is filled by dropping the ink between the nibs while held in a nearly vertical position. In drawing, the pen is held between the thumb and forefinger. The flat side of the point is laid against the edge of the T-square or triangle and the pen held within the plane of that edge. The taper to the point is sufficient to throw it far enough from the edge to prevent blotting. The handle should be tilted about 35° to the right of perpendicular.

SCROLL.—The scroll is used in obtaining curves other than arcs of circles. By trial, a section of the scroll is found that corresponds with the desired curve. It is sometimes necessary to obtain the curve by applying different sections of the scroll in succession.

LETTERING.

All lettering should be free-hand, and may be done with the drawing pen used as an ordinary pen, or with a stick sharpened so that the point will give the desired thickness to the letter. It is desirable to confine lettering to one or two standard alphabets that are plain and distinct and the principles of which are easily acquired. Such alphabets are here shown.

The basis of the capitals in the vertical font is a circle, and an oval in the inclined font. Draw lightly in pencil, four horizontal lines $\frac{1}{16}$ inch apart. The letter O is a circle, and the letters C, D, G, Q, S and U are modified forms of the O. The cross pieces of the A and G may be upon the second line from the top, and the cross-pieces of the B, E, F, H, P, R and S may be just below the first line from the top. All letters may be of the same width excepting I, J, M and W. Make the outside lines of the M parallel. W is formed of two V's. In the figures

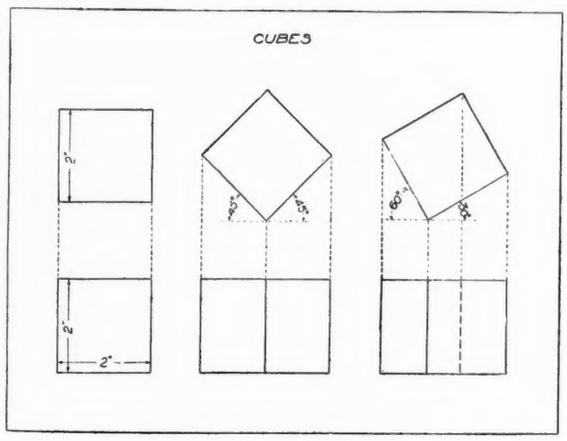


FIGURE 3.

the circle is still the basis. See that the top of the 4 is closed. The division line of the fractions should be horizontal. Indicate feet thus, ′, and inches thus, ″. In the lower case letters, the o is the basis of a greater number of letters than in the upper case: a, b, d, g, p and q each contain the o complete, with the addition of a straight line; c, e, h, m, n, s and u each contain a part of the o form. The o is $\frac{1}{8}$ inch in height and letters protrude above or below the line $\frac{1}{16}$ inch.

Either the vertical or the inclined fonts may be used, but the latter is generally preferred.

GENERAL NOTES.

All drawings are made in pencil, and inked in afterwards if desired.

Having tacked the sheet on the board, draw the marginal lines as shown in Fig. 1. When the sheet is finished it should be trimmed down to these lines, thus cutting out the holes left by the tacks. The "sight," or part containing the drawing, is 9×12 inches. On the top, bottom and right-hand side, a margin of $\frac{3}{4}$ inch is left. The larger margin on the left permits of binding when the series is complete.

In order that the sheet may have a symmetrical and orderly appearance, ascertain the number of views it is to contain and the approximate space each view will occupy.

The utmost care should be taken to prevent the soiling of the sheet.

SHEET ONE.

This sheet gives the top and front views of a cube shown in three positions. Draw a 2-inch square as shown in the upper left-hand corner, using the upper edge of the T-square for the top and bottom lines and a triangle resting against the T-square for the sides. Continue these side lines below the lower horizontal line, thus obtaining the side lines of the front view, and draw the top and bottom lines two inches apart. The two views required are now completed. After the drawing is finished the dimensions should be put on. As a cube has length, breadth and depth, three measurements should be given. The

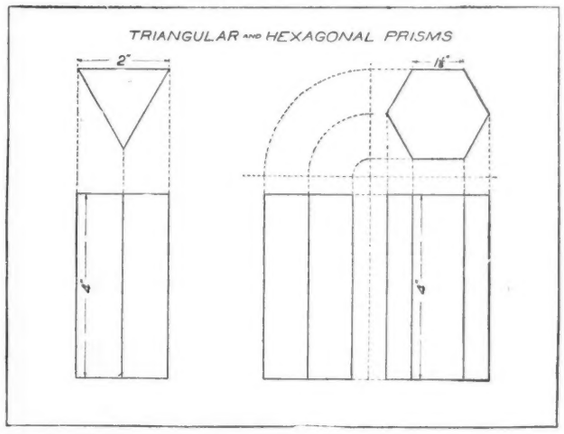


FIGURE 4

length and breadth are here shown on the front view and the depth on the top view.

In the center of the sheet the cube is shown turned at an angle of 45°. The top view must first be drawn and is obtained with the 45° triangle. From the corners, lines are dropped as in the first case, and the top and bottom lines are again drawn two inches apart. The result is the required front view. It will be noticed that in this view two faces are seen, while in the first case only one is seen. However, these faces do not appear as wide as in the first case. The one gives the true width of the face, while the other gives what is termed a "foreshortened" view. Never give dimensions of a foreshortened distance.

In the third case the top view is turned so as to form angles of 60° and 30° with the horizontal. The 60° and 30° triangle is used in drawing this view. As in the previous cases vertical lines are drawn from the corners downwards and the front view completed. It will be seen that whereas in the second case the front and back edges of the cube coincide in the front view, in this case the back edge falls to the right of the front edge and is hidden. This is shown by putting in the back edge with a broken line, called a "hidden line." Hidden lines are made up of a number of short lines $\frac{3}{16}$ inch in length, with a slight space between them. The lines here used in showing the relation of the top and front views are called "construction lines," and are a scant $\frac{1}{8}$ inch in length. These instructions for hidden and construction lines apply only to inked lines. In the pencil work they should be continuous and light.

When the drawing is finished in pencil it should be inked in, putting in all horizontal lines at first, then the vertical and the oblique lines. Finally, put in the dimensions and the title.

The dimension lines should be made lightly and the arrow-heads sharp and with the points resting upon the lines that they give the distance between. The figures should be ⅛ inch in height, and distinct. Great care should be taken to observe this rule, as it is from the figures that the machinist works, and it is only just to him that they be made readable.

SHEET TWO.

Triangular and hexagonal prisms. Prisms are solids having their ends parallel and the edges formed by their sides parallel lines, and are known as triangular, hexagonal, etc., from the form of their bases.

First draw the equilateral triangle for the top view, using the 60° triangle for the sides, and complete the two views with the dimensions given.

In the case of the hexagonal prism, three views are shown; the top, front and left-hand views. To obtain these, first draw a hexagon with 1⅛ inch sides. This is best done by drawing

the lower line and cutting off the desired length. Then with the 60° triangle draw the lower side lines and cut off 1⅛ inch. The upper side lines are also drawn with the same triangle and the hexagon is completed by adding the top line. The front view is obtained as in the case of the triangular prism. The height in the side view is the same as in the front view, and distances from side to side are obtained directly from distances from top to bottom on the top view. This relation of the top and side views is shown in the drawing by the construction lines, and should not be considered as a part of the finished drawing.

EXERCISE I.

Square Prisms.—Draw the top and front views of a square prism, the base of which is 2 inches square and the height 4 inches. Show three positions as in sheet 1.

EXERCISE II.

Triangular and Hexagonal Pyramids.—A pyramid differs from a prism in that its sides meet in a point. Draw the top and front views of a triangular pyramid 4 inches in height and having each side of the base 2 inches. Also draw top front and left-hand views of a hexagonal pyramid 4 inches in height, having each side of base 1⅛ inch.

Compasses, with pen, pencil, needle point and length bar	$2.00
Drawing pen	.50
Drawing board	.40
45 deg. triangle	.35
30-60 deg. triangle	.35
Scale	.40
Ink	.25
Pencil	.05
Eraser	.05
Thumb-tacks	.05
Sheet of drawing paper	.05
Total	$4.45

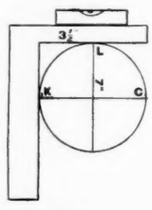


FIG. 2

* * *

SETTING ECCENTRICS OF LOCOMOTIVES.

Fred E. Rogers.

In years gone by it was the common practice in locomotive construction to fasten the eccentrics to the axle by cupped set screws. These constantly gave trouble by working loose, and slipped eccentrics were of common occurrence, often delaying trains and causing serious accidents.

At the present time it is a nearly universal custom to key or feather them on in addition to the screws. These feathers are about 3¾×1 inch wide and ⅝ inch thick, and are set in the axle ¼ inch.

As is usually done and which is undoubtedly the correct practice, the eccentrics are gripped on the axle by the set screws alone until the valves are set and the positions are accurately established, then the eccentric rods and straps are taken down, the key-ways marked off from those already in the eccentric, and then they are chipped with the hammer and chisel.

On steel axles and in the constrained position it is a slow and tiresome job and a thankless one at that, for at this period the other work is done and this is the last operation.

To avoid this, various plans have been tried to find the correct position while the wheels were yet on the floor. None of these are perfectly accurate on account of various defects and lost motion of parts, but the following method has been found to be close enough for all practical purposes.

The first thing to be done is to place the main wheels on a piece of level track, with one crank pin in a vertical position over center of axle. To find this we scribe on the end of axle a circle the exact diameter of crank-pin at collar next to the wheel. Then over the pin hang a pair of plumb-bobs, with line connecting, long enough to hang below axle. (See Fig. 1.) Make these lines coincide with the periphery of circle; when this is done the crank pin is on the exact top quarter.

Now on the axle between the wheels at a proper distance from them we find the exact top point of axle which lays in the projection of the radial line drawn through crank-pin center, by method shown in Fig. 2. The axle shown is 7 inches in diameter, and square has 3½ inch mark from inside edge. When level shows fair this point is marked on the axle at A, then square and level are reversed to other side of axle, and if the points coincide the mark is correct, if not divide the difference.

Now from this point, found with a pair of long dividers with curved points, quarter the axle. This will give the two quarter marks B and C. The eccentrics, previous to being placed on the axle, have all been centered at throw and bore, and a line drawn through them (Fig. 5.) By making this line coincide with the quarter marks we can set them at right angles to the crank, but with the lap and lead they have to be advanced *towards* the crank instead of from, as in a direct connected engine.

This amount of advance is found by laying out the diagram, Fig. 4, full size; the outer circle represents the axle and the inner one path of eccentric center. If the valve is ¾ inch lap and it has $\frac{1}{16}$ inch lead we have to throw valve $\frac{13}{16}$ inch from center line of ports. Our rockers are 11 inches at top end and 10 inches at bottom end. By striking arcs with these respective radii and laying down on the outer arc $\frac{13}{16}$ inch it will subtend on the inner one the

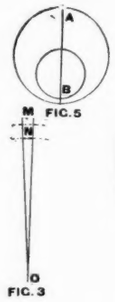


FIG. 3

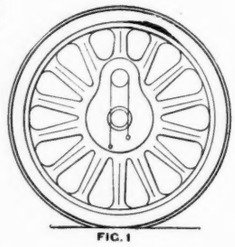


FIG. 1

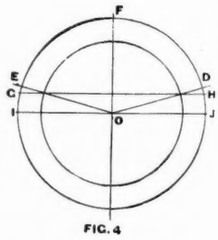


FIG. 4

amount the lower end of rocker-arm is thrown out of the plumb line. Now we lay line G H, Fig. 4, parallel to A B at the distance found. At the points where this line intersects the eccentric path draw the radial lines E C and D C; A E and D B will be the distance the center line of the eccentrics will be moved from the quarter points.

This work has to be done with extreme care to get satisfactory results, and the results will be more accurate on long eccentric rods of say 60 inches radius or over. On shorter ones the angularity of the eccentric rods to the links has the effect in most engines to increase the amount of lead given, and some allowance has to be made for this. On 36 inches radii decrease advance about ⅛ inch. This method applies to center-line locomotives. Those in which the lower rocker-arm is below center line of cylinder have advance of backward eccentric decreased and of forward ones increased, in direct proportion as radius of motion is to amount rocker is below center line so is radius of axle to x.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

CUBE ROOT.

W. L. CHENEY.

This article assumes that it is understood how a *square* is made up and the principle on which square root is extracted, as explained in a former article on *square root*.

With this understanding we will proceed to investigate the manner in which a *cube* is constructed. The cube of 12 (12 times 12 times 12, or as expressed in signs, $12\times12\times12$) is 1,728, and considering that the 12 is composed of 10 and 2 (on account of the *custom* of giving a value of ten times what the figure itself represents, for each place to the left occupied by the figure, as explained in the article on square root), we find the cube of 1,728 to be made up as follows:

10 cube	1,000
3 times 10 square times 2	600
3 times 10 times 2 square	120
2 cube	8
Total	1,728

"Pointing off" the number 1,728 into "periods of three" (for the same reason that we point off into periods of two in square root), we proceed to extract the largest cube from the left hand period, in this case 1, the cube root of which is evidently 1 also, so that we now know that we have found the 1 *ten* that went to make up the cube 1,728, and as the cube of the 1 *ten* is 1,000, we now must consider the remaining 728, which we know to be made up 3 times 10 square times 2, plus 3 times 10 times 2 square, plus 2 cube, as shown above; but as 2 is the number we are now seeking for, we must assume that we do not know what it is, in order to be able to find it when we really do not know in actual practice.

Whether it is 2 or any other number, we know it cannot be a very large number, as it *must* be *units* (as we have already found what the cube root of the *tens* is), and cannot therefore be over 9.

It follows then that the remaining 728 must be made up *principally* of 3 times 10 square, plus 3 times ten, multiplied by something which will make *nearly* 728, and by using this 3 times 10 square, plus 3 times 10, for a *trial divisor*, we get a *hint* of what the "something" wanted is.

As this sum (330) will go into 728 a little over twice, we think that 2 is the number we are looking for, and to see if it really is the number we want, we must carry it through with the rest and see how we come out.

As we know the remaining 728 to be made up of 3 times 10 square times 2, plus 3 times 10 times 2 square, plus 2 cube, we know also that if we remove the factor 2 from these quantities, that is, divide them by 2, we shall obtain a quantity, which, being multiplied by 2, will give us the original quantities back again; this being self-evident.

Dividing these quantities by 2, we obtain 3 times 10 square (the 2 left out) plus 3 times 10 times 2 (one of the 2's left out) plus 2 *square* (one of the 2's left out again).

By making a divisor of the sum of these quantities, which amount to 364, we find it goes exactly twice into the remaining 728, and therefore know that 2 is really the *units* figure that we have been looking for.

To reduce to a formula: The cube of $a+b$ is $a^3+3a^2b+3ab^2+b^3$ (a=10 and b=2 in this case), after taking away the a^3 we evidently have remaining $3a^2b+3ab^2+b^3$, as we do not know what b is, we take $3a^2+3a$, which is what remains with the b left out altogether, for a *trial* divisor, and by assuming the approximate quotient to be the b that is sought, we take $3a^2+3ab+b^2$, which is $3a^2b+3ab^2+b^3$ *divided* by the b, and multiply it by the b back again, to see if the b we have assumed is really the b we have been looking after.

In the case of 1728 we find that it completes the cube, and that b is really 2 and so know that we are right.

Therefore (knowing that we are right), if there should be a remainder after taking the result of this final multiplication out of what is left of the original number, we would know that the number was not a perfect cube, and would take what is left and annex ciphers for another period, or as many more periods as required for the degree of accuracy needed, same as in square root.

As no one can be thoroughly *independent* of *rules* for extracting square and cube roots, without understanding how these formulas are made up, it is recommended that elementary algebra as far as multiplication should be studied and understood; this is a simple matter, and when once understood, by following out the principles involved in these two articles on square and cube root, *any* root can be extracted without asking for a rule.

This will be thoroughly explained in a later article.

* * *

COLORS OF PATTERNS AND CORE PRINTS.

In common with many other concerns the Ferracute Machine Co. has adopted black as the standard color for its patterns upon all sufaces representing cored surfaces of the casting. All core prints are colored red, both where they project from the pattern and wherever a core would appear in section, at all points thereof, for the core is supposed to be imbedded in the pattern in proper position. This following out of the shapes of the core, so to speak, with red varnish is frequently of great convenience to the moulder as well as the patern-maker in understanding which way about a core is inserted, how deep it goes, etc.

The Ferracute people color all prints other than core prints, such as are used for the placing of shafts, studs, staples and other metal work which is to be "cast in," blue; this being suggestive of the wrought iron which is generally used for such purposes.

All joints of the pattern proper, except those occurring in the territory occupied by the core, of a yellowish tint, just as the varnish appears on the natural pine wood—doctoring up with yellow varnish places which happen to be of any other color, as, for instance, if made of metal or of dark colored wood, leather, putty, etc. By this system it is always easy to know whether a pattern is complete or whether it is only a part of the whole, which of course is always indicated where there is any yellow surface.

In choosing the solid colors, such as black, blue and red (these being produced respectively by mixing lampblack, ultramarine and vermillion with shellac varnish), defects due to leather, putty, and other materials incident to cheap construction, can be covered up, and a handsome looking pattern with a uniform surface can be produced. The joints before referred to, which are not covered are usually the easiest to make of a neat appearance by reason of their simple shape, and furthermore they are hidden when the pattern is put together. For these reasons this pattern is by many concerns preferred to the one often adopted where the pattern itself is yellow, and the core prints black, or *vice versa*,

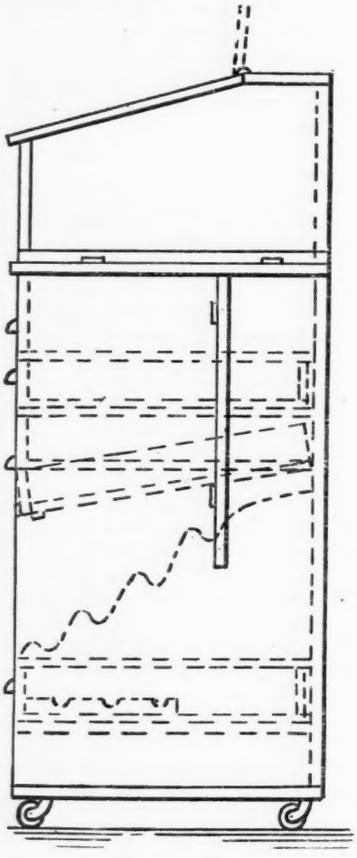
* * *

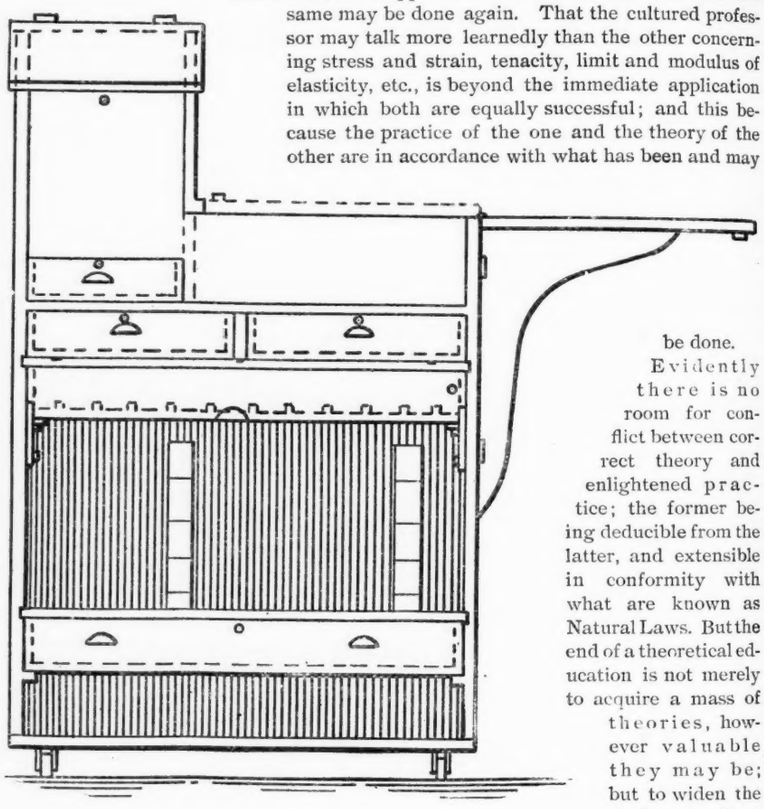
In reply to our criticism of that portion of *A Library of Steam Engineering*, which seemed to give undue prominence to a new type of compound engine, the author, Mr. John Fehrenbatch, states that such was not his intention, and that it was solely the novelty of the arrangement that led to its selection for use in the book. While we cheerfully acquit the author of any intention to push the engine, we cannot help thinking it would have been much better to have at least named the more prominent types of compound locomotives instead of allowing the inference we suggested. The makers also take exception to our remarks concerning the engine, but we see no reason for altering the opinion expressed. As we said before, this in nowise affects the value of the other portions of the book.

AN INSPECTOR'S TRUCK

In these days of interchangeable parts and of working to thousandths, inspection is a very important part of the machine-shop economy, and every pains should be taken to make it not only thorough in the first place, but inexpensive in the second. There are many machines, like dynamos, machine tools and the like, which cannot well be brought to the inspector; so if the mountain will not go to Mahomet, Mahomet must go to the mountain. In order to enable this to be properly done, with an economy of time and money, and without cluttering up the benches and thus interfering with the workmen, something like the truck which is here shown should prove valuable in many shops, as it has before in those of the Brown & Sharpe.

As shown in front and side views, there is a desk-like structure having one part, that to the right, about 34 inches in height, including the castors (which latter should properly be rubber covered), and the other part, to the left, as high as is convenient for the inspector to write at. That part to the right is flat; that to the left sloping forward. The former may be made wider by a flap, which folds down and may be brought up and held rigid in a horizontal position by a hinged swinging bracket. There are





compartments for the books and stationery necessary for the record, and others for small gages and tools; and besides these there are racks below for long screw-drivers and other pieces, which may thus be more handily kept. The illustration is practically self-explanatory, and the idea is commended to dynamo builders, makers of machine tools, steam engines, etc., as well as to manufacturers of sewing-machines, typewriters and other small, delicate machines.

* * *

THEORETICAL EDUCATION AND PRACTICAL EXPERIENCE.

G. W. Scott.

Time was, when the so-called practical man looked with suspicion or contempt on the individual entertaining a leaning towards a theoretical or scientific knowledge, and he would be likely to indulge in more or less sarcasm and irony whenever the educated one ventured to speak of other than the most cherished and conservative practice. But all this is rapidly fading away; not so much perhaps, by superiority of either theory or practice, but rather because of the better commingling of the two, and the gradual disappearance of the notion that an impassable barrier lay between them. That any hostility should ever have occurred is probably accounted for by the reluctance with which new ideas are accepted. In fact ideas are rarely accepted on first presentation, but invariably become common property only after repeated expression has induced an appreciable impression. True, in the early days of modern engineering, much that passed for theory would have been better termed otherwise; and the confusion of result not conforming to prediction afforded some reasonable ground for the skeptical attitude of the merely practical worker.

Primarily, a theory is associated with some form of practice; even the most metaphysical theory being based on certain premises—subjective or objective. But in our own walk of life—Mechanics and Engineering—all proper theories are necessarily based on some observed fact or practice. The theory may not always be a correct one, but the intention is undoubtedly in the direction of accuracy. And, therefore, the least educated of workmen, who knows, by his own experience and that of his immediate fellows, that a 1-inch square bar of iron will support in safety a certain load, is as much a "scientist," so far as this particular case is concerned, as the most cultured professor of engineering. Either one relies on a knowledge of what has been done, and supposes that under similar conditions the same may be done again. That the cultured professor may talk more learnedly than the other concerning stress and strain, tenacity, limit and modulus of elasticity, etc., is beyond the immediate application in which both are equally successful; and this because the practice of the one and the theory of the other are in accordance with what has been and may be done.

Evidently there is no room for conflict between correct theory and enlightened practice; the former being deducible from the latter, and extensible in conformity with what are known as Natural Laws. But the end of a theoretical education is not merely to acquire a mass of theories, however valuable they may be; but to widen the understanding, bringing us in touch with what has been done in the past, and enabling us to become acquainted with what is going on in the present; and thus fortified, to exercise our better usefulness. Without education, dependent on our own limited personal experience, one's knowledge would be sadly restricted. The crude "scientist," already referred to, may know well enough what a 1-inch square bar of iron will support, but his lack of education and theory might place him in a quandary if called upon to state the safe tensional capacity of a rod of irregular section with which he has had no previous dealings.

And how shall this theoretical education be acquired, seeing that few can hope to enter the Universities, and only a limited number be received at the technical and manual training schools? This may appear a grave difficulty; but it is not entirely insurmountable, for, in these days of comparatively low-priced books—not to mention the many excellent trade papers none the less educational because not generally posing as such—one may do much without the educational institutions mentioned. An ordinary school education, and the willingness to study in the evening, or during hours of leisure, is an excellent basis for the acquisition

of knowledge. And thus prepared, the willing aspirant may take his choice from a wide and generally well arranged series of text books. In some cases the student may be so located as to take advantage of evening classes devoted to elementary science teaching; but if not, he may procure text books on the subject with which he desires to become familiar, and then proceed to realize the exquisite pleasure of knowledge resulting from personal effort.

One cannot long pursue even an elementary study of a scientic subject without making acquaintance with others; the connection being of the most intimate nature, and the same fundamental laws and principles ruling in each. And thus it is, the mind rapidly broadens to a conception of the mighty truths which were before as if non-existent. The quickening mind becomes more observant, more reflective. Things that were before of a seemingly inexplicable nature are now readily comprehended by the added intellectual light. Nay, more; for the student can then recognize, in a thousand ways, that which before was passed by because of lack of the talismanic power of knowledge; and there is now open for his observation a wealth of conditions in the various fields of natural phenomena.

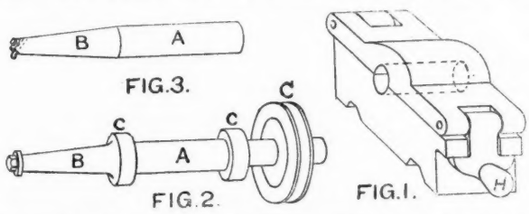
And while pursuing these fascinating studies the student will have ample opportunity to apply some of them to his daily work. To the student in the foundry, machine or engine works, is given a practically unlimited field for observation and reflection. No longer would the student-worker be satisfied with the dictum—"We have always done it this way;" but applying his knowledge would endeavor to demonstrate why certain defective practices should be managed differently, or an entirely new method adopted. In his zeal he might make a few mistakes—he probably will; most of us do so in any case—but better this than mental servitude to an unprogressive conservatism, and in the end the mistakes will be more than balanced by successful innovations and helps to a higher advancement. It was written by the philosophical Lord Bacon, that "Truth more easily comes out of error than out of confusion." And surely of all confusion, that of ignorance is the most hopeless. To the reflective mind seeking causation for manifested effects, as well as determining the means to produce desired effects, the occasion of an error is an object lesson, in more ways than one, from which profit will result to be applied with advantage in future cases.

Here, indeed, is the close companionship of knowledge merging into wisdom guiding the practical pursuits of the worker. An intermingling of interest is the result—practice modifying or advancing theory, and theory reaches out ahead directing practice.

* * *

A SPECIAL LATHE FIXTURE.

The engraving illustrates a special foot-block or tail-stock, used in boring and grinding the iron body plug-cocks used in refrigerating work. Fig. 1 shows the foot-block, which has a hinged top, locked by the lever in front. For boring, the bar shown in Fig. 3 is used, the body A being clamped in hole in foot-block. After boring they are ground without being removed



from the chuck, by substituting Fig. 2 for Fig. 3 in foot-block, the body A running in bearing, held by collars at each end, while B carries emery wheel, the whole being driven by pulley C. This makes a very neat device, and is only one of the many special tools of the kind in use at the works of the De La Vergne Refrigerating Co., New York City.

* * *

To Soften White or Silver Iron so that it may be drilled or chipped, put it into a steel furnace, or other converting furnace, together with a suitable quantity of ironstone, iron-ore, some of the metallic oxides, lime or any other combination of these substances reduced to powder, or any other substance capable of combining with or absorbing the carbon of the crude iron. The more or the longer the heat is applied, the more nearly malleable the iron will become.

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

13. Gears, Kingston, N. Y: 1. See article on this subject in our next issue.

14. W. H. B: 1. We do not see how there can be any vacuum in the back pressure end of the high pressure cylinder unless there is a very leaky valve in low pressure cylinder, or the rod packing is so worn that there is an opening through between the cylinders. Of course this cannot happen unless the cylinders are so arranged that the rod is not exposed between the cylinders.

15. K. T. T., Elmwood, Wis.: 1. An engine is usually indicated under both light and full loads, and cards should be taken at short intervals to secure a fair average. 2. Does a dynamo require any more power to run when generating electricity than an equal amount of iron would under the same circumstances, regardless of electricity. *A.* When running idle the power required to run armature is practically that due to its weight. When generating electricity the required varies with the load in "watts." In other words, each lamp thrown in circuit adds to the power required. If this were not the case we would be getting "something for nothing" and electricity would be very cheaply produced.

16. Feed Water, Sterling, Ill. 1. It is impossible to tell without an analysis whether the scale forming matter in the water will be precipitated in the basin or not. Heating feed water will help if water has lime or magnesia. 2. Your plan for removing oil from drip well seems to be all right, and if oil is carefully filtered it should be good to use again.

17. H. J. D., Bayonne, N. J., asks: 1. Does an engine run faster at one end of the stroke than at the other? *A.* You evidently refer to the piston, and this runs slower at each end of the stroke than at the center. 2. You will find terminal and mean effective pressure explained in the November number, question number 12. 3. You do not give either cylinder diameter or revolution per minute, yet ask for horse power of engine. 4. Compound condensing engines will be treated later in an article by a well known engineer. 5. Horse power of a pump can be calculated by same means as engine if we find mean effective pressure by indicator, or perhaps more easily by measuring amount of water and pressure against which it is delivered. If a pump forces 1,000 gallons per minute to a height of 100 feet, the work done is $1{,}000 \times 8.3 = 8{,}300$ pounds $\times$ 100 $= 830{,}000$ foot pounds, as a gallon of water weighs 8.3 pounds. This divided by $33{,}000 = 830{,}000 \div 33{,}000 = 25.1$ *effective* H. P. As each foot of height $=$ .434 pounds pressure we can convert pressure into height by dividing by .434 as, if instead of forcing 100 feet high, the pump forced into a boiler carrying 100 pounds pressure we have $100 \div .434 = 230.4$ feet, or 100 pounds pressure is equivalent to the pressure due to a head of 230.4 feet.

18. J. Y. M., Richmond, Va., asks regarding the adjustment of the Coale safety valve: Referring this to Mr. F. W. Coale we find that you have misunderstood the instructions. Raising the seat ring restricts the opening and reduces the area for escaping steam, and confining the steam in the pop chamber causes the valve to blow longer and lose more steam before closing.

19. M. J., Kal. Co., Mich.: 1. The clipping you send is another attempt to get "something for nothing," which is against all natural and mechanical laws. To move weight requires power, and while some methods of work are more efficient than others, the weight cannot be so placed as to move itself (except down hill). While it is possible to make a weight run a train of gears so as to propel itself, the weight must be first lifted and thus repeated whenever it runs down. Mr. Christy's bicycle is another of the many mechanical delusions which are expected to *create* power.

20. E. L. B., Collinsville, Ill., asks: 1. What length of connecting rod should an engine of 2½ inches stroke have? *A.* Stationary practice usually makes the connecting rod between 2½ and 3 times the length of stroke, or from "5 to 6 cranks," as it is commonly expressed. High speed engines are usually from 4½ to 5 cranks long, or 2¼ to 2½ times the stroke. Marine engine rods are sometimes made shorter yet, but 2½ to 3 can be called good practice. This would make your rod $3 \times 2\frac{1}{2} = 7\frac{1}{2}$ inches from center of crank pin to center of crosshead or wrist pin.

21. C. L. B.: 1. No pump can "lift" water 60 feet, 30 feet is a very

high lift and not usually attained. 2. There is no such thing as high pressure without power, whether by stagnant water or anything else. 3. Tandem engines have the high and low pressure cylinders in line with each other and one piston rod runs through both. Triple expansion engines are also sometimes arranged in this manner. 4. "Priming" occurs in the boiler, and superheating the steam after it is made will not stop the priming. It will, however, overcome the bad effect on the engine by drying the steam (evaporating the moisture) before it goes to the engine. 6. Will answer this later.

22. F. C. B. writes: 1. I find in the Encyclopædic Dictionary the statement that "the radiation of heat is inversely proportional to the square of the distance." If a thermometer registers 40 degrees at a distance of 10 feet from a heater, what will it register at a distance of 15 feet? *A.* By this formula we have the proportion $15^2 : 10^2 :: 40 :$ answer, or $225 : 100 :: 40 : 17.7$ degrees. 2. What is meant by "inversely proportional." *A.* Taking the above example we can say that if it said "the radiation is in direct proportion to the distance (or square of the distance)," the answer would be found by saying as $10 : 15 :: 40 : 60$, or if squares, as $100 : 225 :: 40 : 90$, but when it says "inversely" we know the answer must be less and so reverse the proportion as above. Of course common sense says the temperature will be less the greater the distance from the source of heat, and this also agrees with the formula given. For confined spaces, such as a cellar, we should not place too much dependence on this formula except at very short distance. The law is probably correct when not affected by such conditions as confined air or disturbing drafts.

* * *

FOR THE NOTE BOOK.

IN THIS COLUMN WE PUBLISH PRACTICAL RULES AND DATA THAT WILL BE FOUND USEFUL TO SHOPMEN GENERALLY; AND WE SHALL BE PLEASED TO CREDIT ANY CONTRIBUTION THERETO.

QUESTIONS CONCERNING ANY OF THESE NOTES WILL RECEIVE CAREFUL ATTENTION.

COMPOSITION OF AIR.

It may avoid confusion and error in the future to note that when the constituent parts of air by weight:

23 parts of oxygen and 77 parts of nitrogen.

By volume:

21 parts of oxygen and 79 parts of nitrogen.

ABSOLUTE TEMPERATURE.

In compressed air calculations there is frequent reference to *absolute temperature.* By the Fahrenheit scale, the one in common use, this is the temperature indicated by the thermometer plus 461 degrees. Thus, at 60° by the thermometer the absolute temperature is $60 + 461 = 521$ degrees.—*Compressed Air, by Frank Richards.*

SPIRAL SPRINGS.

The effective number of coils is generally two less than the apparent number, owing to flattening of ends. The stroke of a spiral spring is the effective number of coils multiplied by compression or extension of each coil. The diameter of coil should be about eight times the diameter of the steel of which it is made. The following formula gives the extension or compression of spiral springs under a given load:

$$E = \frac{D^3 W}{d^4 c}$$

Where E = compression or extension of one coil in inches.

D = diameter of coil in inches from center to center.

d = diameter of round, or side of square steel in *sixteenths* of an inch.

W = weight applied in pounds.

c = constant—22 for round steel, 30 for square steel.

A spring is four inches in diameter, center to center, made of ⅛th round wire, what is the extension with a load of 20 pounds?

$$E = \frac{4^3 \times 20}{2^4 \times 22} \text{ (as wire is } \tfrac{1}{8} \text{ or } \tfrac{2}{16} \text{ we call } d = 2).$$

$$E = \frac{64 \times 20}{16 \times 22} = 3.63 \text{ inches.}$$

—*"Practical Engineers" Pocket Book.*

FORMULAS FOR CASTING COMMUTATION BARS.

No. 1:

100 pounds copper.

1 pound oxide of manganese.

NOTE.—Melt oxide of manganese with copper and before pouring fuse in a 2 ounce stick of phosphorus. Pour hot, use coarse sand for molds.

No. 2:

100 pounds copper.

¼ ounce cryolite.

NOTE.—Fuse in a 2 ounce stick of phosphorus. After melting the copper put in cryolite first, then phosphorus.

Dip castings in acid of vinegar, while hot, as soon as congealed.

NOTE.—Phosphorus should be infused in metal by means of a graphite rod which has a ⅝ inch hole extending in one end 6 inches or 8 inches. The stick of phosphorus to be placed in the hole and held there by means of a strip of copper on end.—*The Foundry.*

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

TURNING UP DASH-POTS.

In the shop where I served my apprenticeship (E. P. Allis & Co., Milwaukee) I had a large number of vacuum pots to bore, face the bottom and turn and polish the top. The pots were bored out with a boring bar and held in place by a kind of chuck, with set screws to the lathe carriage; but all this has nothing to do with the gage. After being bored, the pots were turned up on a mandril with split bushings, as in Fig. 1. Seeing others had trouble in making the measurements with scales, in which case of course it was necessary to face the top of the pot, first measuring, we will say, 8 inches, then placing a scale against the top, get the measurement over all and place another scale against the bottom.

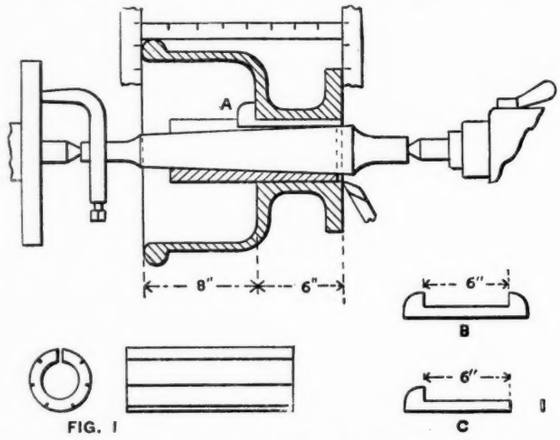


FIG. 1

This I thought was a very scaly affair, and very difficult to do without three hands, unless a straight-edge was blocked up against the top face. The 6 inch part was to be faced to a gage, as B; the 8 inch part was no particular measurement. So I devised a little gage as at C, which I slid right through the slot in the mandril bushing as at A. The pot was driven to project over the bushing, which made it easy to start the cut from gage facing outward. I do not know whether it is new, but I found it very convenient.

Where solid mandrils are used and similar work is done in large quantities, it would pay to cut a slot in the mandril.

St. Paul, Min. ARTHUR MUNCH.

SAYS IT'S NOTHING NEW.

The plan of driving machinery by having a separate belt for each step of the cone pulley and throwing in a tightener on whichever one you want to use, is being talked of considerably in our shop, and great are the expectations of its effect on present shop practice. One objection is the short belts used between the cones, although a friend of mine told me it made a lathe more powerful, *because you could use all the belts at once.* And he is an old

machinist too; but the question of different velocities of the different steps of the cone never occurred to him.

But the device is not new by any means, as any one who remembers Mr. Ed. Clark's saw mill in Benton, Lackawanna Co., Pa., in 1857, will recollect that he used an almost identical device for driving his saws.

This rather antedates the "new" system, and although it was very handy in some ways, it never came into general use even in its own neighborhood, and I'm almost willing to bet my last year's overalls that the resurrected idea will die the same death, due to neglect of its great possibilities.—R. E. MARKS, *Camden, N. J.*

MORE CALCULATION.

In reply to a query concerning the "Trick of Calculation," in September, Mr. Cooper writes:—

Replying to your correspondent, which is hardly necessary, because it would be as trying to prove an axiom to be true:—

It ought not to be difficult to understand that $\frac{3}{10} = .3$ when in decimals, and $\frac{3}{100} = .03$ when in decimals, and $\frac{3}{1000} = .003$ when in decimals, and that $\frac{3}{10} \times \frac{3}{100} \times \frac{3}{1000} = .333$; and we start with letting S = either of them, because they are equal.

This being so, Mr. Dennis can't figure out either one to be different from just what they are stated to be.

I think every part of the process will be proven as correct, as $2 \times 2 = 4$, by every mathematician, and I do not see how any part can be made more clear than it is as shown by your types, except where the types say S $\frac{3}{5}$ they should say $S = \frac{3}{5}$.

Respectfully, JOHN H. COOPER.

DECIMALS.

As MACHINERY is publishing articles on machine shop arithmetic, perhaps some examples showing the application of decimals to shop work might be in order. In turning up gear blanks, sometimes parts of an inch are required which are not found on the ordinary steel scales, and for about any case, changing to decimals, scales graduated into 8ths, 16ths, 32ds and 64ths could be made to answer. For example, suppose it is required to make a gear blank of 60 teeth 28 pitch. Then the pitch diameter of gear would be $60 \div 28 = 2\frac{4}{28}$, and adding $\frac{2}{28}$ to the P. D. we obtain the outside diameter, which is $2\frac{6}{28} = 2\frac{3}{14}$. Now reducing $\frac{3}{14}$ to a decimal we have $3 \div 14 = .214$, and referring to a table of decimal equivalents we find $\frac{7}{32} = .218+$, the calipers could then be set to $2\frac{7}{32}$ minus about the thickness of a line on the scale. For another example, suppose it is required to gear up a lathe which has a lead screw of 6 threads to an inch to cut a worm to mesh with a worm gear of 28 diametrical pitch.

The circular pitch of a worm gear of 28 D. P. $= 3.1416 \div 28 = .1122$ which is the pitch of one thread on the worm. The pitch of one thread on the lead screw of lathe equals $\frac{1}{6}$th of an inch and changing to a decimal $= 1 \div 6 = .1666$. Now the proportion of change gears on lathe should be as 1122 : 1666, ignoring the decimal point in this case, a gear of 1122 teeth on the stud and 1666 teeth on the screw would be correct, but gears of such a large number of teeth would be impracticable.

A simple way to find a close approximation is to divide 1666 by 1122, and we obtain $\frac{1}{1.48}$ or 1 : 1.48 :: gear on stud : gear on screw; now multiplying both terms of the proportion by 24 we get $\frac{24}{35.52}$, which is nearly gear on stud 24, gear on screw 36.

In order to find the amount of error by using these gears we multiply the pitch of lead screw by $\frac{24}{36} = \frac{24}{36} \times .1666 = \frac{36}{3.9984} = .1111$ now subtracting this from the required pitch $.1122 - .1111 = .0011$ which is so small an error that it could be ignored.

Providence, R. I. JOHN T. GIDDINGS.

CALCULATING MACHINES.

We notice in the October issue of your esteemed paper an article on the Calculating Machine which does not seem to be prepared with the care and regard to accuracy to which you have accustomed your readers.

Perhaps it is too much to expect that an article should be strictly objective when a manufacturer undertakes to compare his own products with other goods, but even allowing for a subjective element in the article it contains some statements which should not go unchallenged, because they are not correct nor fair to others. The article speaks of a maker of such machines as "Thomas de Colmar," of "Colmar's invention," "Colmar's scheme," "Colmar's device," etc. Considering that Colmar is the name of a town in Alsace, in which Thomas lived, these designations are hardly permissible.

The priority of putting the principles of the culculating machine into working shape is attributed in your article to this "Thomas de Colmar." Prof. Reuleaux in his monograph on the subject, the result of exhaustive and painstaking investigations, says that these principles were originally put into working shape by B. M. Hahn between 1770 and 1776. His machine was exhibited in 1876 at the Exposition of Scientific Instruments, at the South Kensington Museum. The main difference between his machine and that of Thomas (not de Colmar) is that the figures on the plates of this machine are arranged in circles instead of straight lines. When exhibited the machine was in good working order up to 12 places, having been restored by Mr. Burckhardt.

The Royal Technical High School, in Berlin, possesses another calculating machine also on the same principle, still in good working order, which was made by one Schuster in 1789–1790. Another such machine was constructed by J. H. Muller, a Captain of Engineers, in 1784. The Thomas machine was constructed in 1822, and not in 1850 as your article states. The monograph of Prof. Reuleaux, from which we take these data, mentions another machine by Leibnitz in 1697, with the figures arranged in straight lines (not in circles). This instrument is still in existence at the Library of Hanover, but has been out of working order for more than a century. It was sent to Mr. Burckhardt in the early part of this year, who is now at work on it and hopes to restore it.

The inaccuracy of the historical part of your article is, however, put in the shade by the bold trade statement that the Burckhardt machine is "poorly made and fragile." This is an altogether unfounded statement, and in drastic contrast with facts. We have before us a letter of this year from the author of your article which states of his machine: "It does not, as now made, compete with the Burckhardt machine, but many would prefer it because the price is much less, and the capacity sufficient for most practical work." This statement is not modified in his letter in any way. The Burckhardt Works turned out their five hundredth machine as early as 1892, certainly a very good result to attain with a "poorly made and fragile" machine. It is also a practical endorsement of Mr. Burckhardt's that the government has entrusted him with the restoration of the Hahn and Leibnitz machines, which are valued very highly and considered of great importance. This work would certainly not have been entrusted to a maker who turns out "poorly made and fragile" machines. As we are selling many of the Burckhardt machines we are in a position to know how they are made and how they wear, and we wish to defend them against such unwarranted assertions as are contained in the article above referred to.

(Firm of KEUFFEL & ESSER CO.) HERMANN ESSER, Treasurer.

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CINCINNATI PUSH.

THE J. A. FAY & EAGAN COMPANY SENDS AN AGENT TO SOUTH AFRICA.

Away down below the Equator, in the extreme southeastern African country, there is a region that is stirring the commercial world as no other territory is doing to-day. Its resources baffle adequate description—diamond and gold fields, coal mines, agricultural and grazing lands, milling enterprises—all are capable of unlimited development. In this wonderful land—known as "South Africa"—Cincinnati push and enterprise has found a foothold. Cincinnati has the most extensive establishment in the world for the manufacture of wood-working machinery of every description—the J. A. Fay & Eagan Co.—of which Mr. Thomas P. Eagan is president and active manager, and with that aggressive and determined spirit that has dominated their efforts for trade, they have penetrated this rich country and are securing and receiving orders for their tools with really surprising frequency. So extensive has become their interests in that region that they find it advisable to send a representative there to take charge of it, and in a few days their Mr. Edgar C. Seebohm will sail for Johannesburg to not only put in practical operation a great lumber plant, equipped with their latest tools, but to personally assume control of their extensive operations in that field.

It is a tribute to American skill, to American brains and to American enterprise, that in a territory controlled by British capital and under British government, whose enterprises are almost

entirely calculated from a British standpoint, American woodworking machinery is recognized as superior to that of their own manufacture.—*Cincinnati Commercial Gazette.*

* * *

MR. JAMES E. WOODBRIDGE, for many years manager of the small tool department of the Pratt & Whitney Co., has connected himself with the Brady Mfg. Co. as its president.

* * *

IN reply to a query, Mr. Winthrop Ingersoll states that the "cutter diameters were figured at tooth-seat instead of at cutting face," which will clear up an apparent error.

* * *

MANUFACTURING NOTES.

THE SOUTH BEND PAPER CO., of South Bend, Ind., are putting in operation at Big Island, Va., a large paper and pulp mill. They are fitting up a machine shop in which to do their own repairing, and have ordered from the Lodge & Davis Machine Tool Co., of Cincinnati, Ohio, the necessary tools for same.

ARMSTRONG BROS.' TOOL CO., 78 Edgewood Ave., Chicago, Ill., announce that they are the agents for the Dayton Gas and Gasoline engine for Chicago and vicinity. They have an engine running and will be pleased to show it to any one interested.

THE PNEUMATIC GATE COMPANY, of 101 Washington street, Chicago, Ill., have just closed a contract with the New York, Chicago & St. Louis R. R. for thirty-six crossings, in Cleveland, Ohio., for their purely pneumatic railway gates. Gatemen will each handle from two to four crossings, economizing in the expense of guarding crossings.

THE DIAMOND MACHINE CO., Providence, R. I., are to make an exhibit of their Ball Bearing Grinder and other machinery for the use of bycycle manufacturers, at the Stanley Cycle Show, to be held in London, Eng., in November.

THE ACETYLENE HEAT, LIGHT & POWER CO., Room 733, Bullitt Building, Philadelphia, Pa., have issued a little prospectus showing the advantages of Acetylene gas. As each house can be independent and the use of long mains obviated, it is very attractive to those who have suffered at the hands of gas companies.

THE PENBERTHY INJECTOR CO., of Detroit, Mich., write us that in visiting the State Fair of Missouri, recently held at St. Louis, they found nineteen manufacturers of traction and farm engines with forty engines on the grounds. In looking over these engines they found on thirty-three of them, out of the forty, the "Penberthy" Injector; the other seven having five different makes. They also state that two manufacturers out of those representing the seven engines agreed to use the "Penberthy" Injector in 1896.

A PRIZE of $150. has been awarded to D. F. Cornell, of Westfield, Pa., for an improvement in lathe carriages. The prize is the monthly award of the well-known patent firm of John Wedderburn & Co., who give this sum each month for the best and simplest invention brought to their attention during the preceding thirty days. Cornell was brought up on a farm and had had but little experience in mechanical work when he made this invention. Other recent prize winners in these contests are P. H. Martin, Vershire, Vt., W. P. Gave and E. E. Katz of San Bernardino, Cal., Daniel Brion, Jr., of Bozeman, Mont., and A. L. Simmons, of Geneseo, N. Y.

THE CLEVELAND TWIST DRILL CO., Cleveland, O., are calling particular attention to their "Big Drill" in Section H, Machinery Hall, at the Atlanta Exposition.

THE U. S. Navy Yard at Brooklyn are making some extensive additions to their machine shop department, and have just awarded a contract to the Lodge & Davis Machine Tool Co., of Cincinnati, Ohio, for several heavy engine lathes to be used in manufacturing guns and other ordnance.

MESSRS. GOEPPEN & BROWN, formerly connected with the Ahrens & Ott Mfg. Co., of Louisville, Ky., will engage in the manufacture of plumbers' supplies and brass specialties in the same city, under the firm style of the Enterprise Brass Works. They are now getting their buildings in shape and have ordered their complete outfit of tools from the Lodge & Davis Tool Co., of Cincinnati, Ohio. They expect to be ready for operation within the course of 30 days.

* * *

THE HAPPY HUNTING GROUNDS, ALSO FISHING, OF THE SOUTH.

Under the above pleasing title the Southern Railway has issued a beautiful and comprehensive book appertaining to the hunting and fishing of the States through which that System extends.

This, indeed, comprises nearly the entire South; including Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee and Kentucky, as throughout these States the Southern Railway has its own lines.

The book is written in the happiest style of Mr. William Bruce Leffingwell, of Chicago, and the illustrations are ample and are especially prepared for this particular volume.

This is the first time that such a publication has been attempted, exhibiting in such an attractive manner the almost innumerable resorts for sportsmen in the South.

The publication can be obtained of Mr. R. D. Carpenter, 271 Broadway, N. Y., or through any of the agents of the Southern Railway System.

* * *

FRESH FROM THE PRESS.

THE MERIDEN MACHINE TOOL CO. have issued another little flyer entitled "To Our Inquiring Friends." It opens with a quotation from Pope which should be well considered:

"Be not the first by whom the new is tried,
Nor yet the last to lay the old aside."

THE STEWART HEATER CO., Buffalo, N. Y., have favored us with a neat thermometer, mounted on an attractive card, advertising the Otis tubular feed water heater. Such an ad. is sure to be preserved, and this one will probably be consulted at frequent intervals.

THE WATERBURY FARREL FOUNDRY & MACHINE CO., Waterbury, Conn., have issued another edition of their monthly catalog. One deals with and illustrates thirty-six different machines, including hydraulic, hand, belt and foot power for many purposes. Hydraulic presses, elevators, accumulators and pumps; punching and drawing machines are among those shown, full description being furnished when desired. A line of foot power presses for various purposes is shown in another catalog, which gives details and prices. Either will be sent on application

MESSRS. DONEGAN & SWIFT, 13 Murray street, New York, send us a catalog of the Metropolitan self-contained engine, Manhattan center crank engine, Acme engine and boiler and their well-known line of pumps and appliances.

THE D. W. BOSLEY CO., of Chicago, Ill., send us a neat catalog of their weather strips and window cleaners, which will be of interest to railway men and others. Too few realize the value of weather strips in dwellings and the saving effected on the coal pile. These goods are particularly well made and durable.

THE JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J., have issued a new pamphlet entitled "The Boys' have something to say about Dixon's Pure Flake Graphite," which contains many recent testimonials from locomotive engineers regarding the merits of their flake graphite for lubricating the various parts of the locomotive. These come from about all parts of the country and certainly show that there is merit in this pure flake graphite for lubricating purposes.

MESSRS. CORBITT & BURNHAM, of Chicago, Ill., send us a forcible illustration of their system of printing time-tables so as to make the exact hour readily distinguishable with regard to day and night. Instead of dividing the day at midnight and noon, as is common, the natural division of day and night is observed, and all hours between 6 at night and 6 the next morning are printed white on a black ground. From 6 in the morning till 6 at night are printed in the ordinary way, black on white, making a distinct division which can hardly be confused by anyone. It appears to be a very sensible arrangement, and has been adopted by several roads.

THE LONG & ALLSTATTER CO., Hamilton, Ohio, have issued Catalog No. 18, which is standard size (6x9) and contains 88 pages. It shows very plainly their line of punching and shearing machinery, and there are few requirements for this class of machinery that cannot be met with their regular line of tools. Shears and punches without number are shown, some of the latter being capable of punching 60 holes at a single stroke. Forming by pressure is also a feature of their work as well as drop hammer work, and the book will interest all workers in plate and sheet metal.

WE have been favored with the 1895-96 steam engine and refrigerating machine catalogs of the Frick Company, Waynesboro, Pa., and they are even more interesting than before, if that is possible. There is a large amount of information in both catalogs, and those who are contemplating any work in cold storage or refrigerating lines will find answers to most of their queries in the catalog or red book on this subject. The tables and data which are contained in these catalogs represent the experience of years, and we know of no books in which the engineer can find more solid information than in these. They reflect credit on the enterprise of this company and the skill of its engineer, and the possessor of the catalogs should feel grateful to them for the privilege.

THE NEWTON MACHINE TOOL CO., 2410 Vine street, Philadelphia, Pa., have issued a neat pamphlet which is typical of this age of half-tone engravings. Of the eight pages only one is devoted to reading matter. The views show the exterior and two interiors of their works, and four pages of tastily arranged photographs showing the various machine tools made by this firm. They include milling machines in great variety, cutting-off machines or cold saws, drills and boring mills designed for various uses. The illustrations give a good idea of the line of tools, and details can be had on application.

THE HARDWARE DEALERS' MAGAZINE, New York, are to issue a Wholesale Hardware Directory in January. From the fac simile of the covor, it will be a very neat affair, and will be extremely valuable to those interested in hardware.

LINK AND VALVE MOTIONS. W. S. Auchincloss. 140 pages, illustrated. D. Van Nostrand, 23 Murray street. New York. $2.00.

This is one of the standard works on this interesting subject, and no one who is interested in steam engines can do better than to become familiar with this work. Part I. deals with the elementary principles and general proportions. Part II. gives a short hand method for valve proportion. Part III., general proportions modified by crank and piston connection. Part IV., link motions. Part V., independent cut-off, clearance, etc. The numerous diagrams, the movable valve and the travel scale attached to the back cover add greatly to the value of the book.

There is probably no subject which is more often discussed among engineers, and particularly railroad men, than valve motions, and this will give a clear understanding of it which will be both interesting and instructive. The book needs no recommendation—it is the best of its kind.

QUARTERLY DIGEST OF PHYSICAL TESTS, H. M. Norris, Editor, Riehle Bros., Testing Machine Co., publishers, Ninth and Master Sts., Philadelphia, $1.00 per year. This will begin the new year by giving a digest of tests, arranged under proper headings, which will make it a valuable reference. We wish it success and Mr. Norris has our best wishes.

ELECTRIC TRANSMISSION OF ENERGY. Arthur V. Abbott, C. E. 560 pages, 9 plates. D. Van Nostrand & Co., New York. Price, $4.50.

This is a large volume, printed and bound in the best manner and is sure to attract attention. The transmission of power electrically is an interesting and serious question at present, as the rapid progress of suburban trolley lines and the abandonment of both horse and cable propulsion will show. These are dealt with in a comprehensive manner; the latest practices being given in each case and the whole subject treated in a clear and concise manner, so as to be readily understood by any one with a fair education, a feature so many of these books lack. There are 9 large folding plates of charts for various purposes; mining, power transmitted, etc., etc., which are alone worth more than the price of the book to any one having calculations of this kind to make. These are contained in a substantial pocket and are handy for reference. Engineers and others who are likely to have problems of this kind presented will appreciate this book.

ELEMENTS OF DESCRIPTIVE GEOMETRY. Prof. C. W. MacCord. 250 pages; 280 illustrations. John Wiley & Son, New York. Price $3.00.

Written by a well known authority in this line, it will be accepted as a standard work in elementary geometry, and the student, whether in the shop, drawing room or office, will do well to make himself familiar with its contents. It clears up many of the points which puzzle a student, and which are essential to a thorough knowledge of this phase of mechanics. The question of projections is touched upon, and the problems shown will do much to make any drawings or projections entirely clear to the student. Isometric and cavalier projection are shown and familiarity with these will be useful in making sketches as well as in giving a clear idea to one not familiar with mechanical drawing, as it gives a view of the entire in one drawing. The book will be extremely useful to any mechanic who wishes to advance in this line, and will prove interesting as well as instructive.

PRACTICAL APPLICATION OF DYNAMO ELECTRIC MACHINERY. MacFadden & Roy. Illustrated. Laird & Lee. Chicago, Ill. $1.00.

This is a handy little book of over 160 pages and has the advantage of being handy for the pocket, which makes it more of a companion than a more pretentious volume can be. The engineer or mechanic can carry this in his pocket and study its contents while going to and from work. The fundamental principles of the generation and use of the electric current are clearly explained, and as a knowledge of these are fast becoming a necessity for the engineers, the book will be appreciated by them.

THE "PRACTICAL ENGINEERS" POCKET-BOOK AND DIARY FOR 1896. W. H. Fowler. 307 pages and a complete Diary of 64 pages. 1s. 6d. The Practical Engineer, London, England.

Our bright and enterprising London contemporary issues its seventh annual edition of this Pocket-Book and Diary and it has succeeded in making each year more valuable than the previous one. It compares very favorably with many of the pocket-books of much greater pretentions (and price) and the feature of a daily diary in connection with it insures its being carried and used daily. The work of Mr. Fowler in editing this from year to year can hardly be appreciated by one not familiar with such work, and he certainly deserves credit for his work on this book. Its reasonable price is greatly in its favor and is made possible by the admission of advertising pages, which do not, however, detract in the least from the value of the book and are, in fact, handy for occasional reference.

ALBERT L. COLBURN, New Haven, Conn., has issued catalog No. 5 of his portable Drilling and Tapping Machines, and his Universal Swing Frame Grinding Machines, which are especially useful for large work which requires the tool brought to the work, not the work to the tool. There is a very ingenious device for keeping the driving rope in contact with the pulley, insuring a steady drive and a good efficiency from the ropes. The swing frame grinders will be found extremely useful in such work as molds, and such small work which requires grinding after hardening. Those who are not familiar with these machines should become acquainted with them immediately.

* * *

BUSINESS.

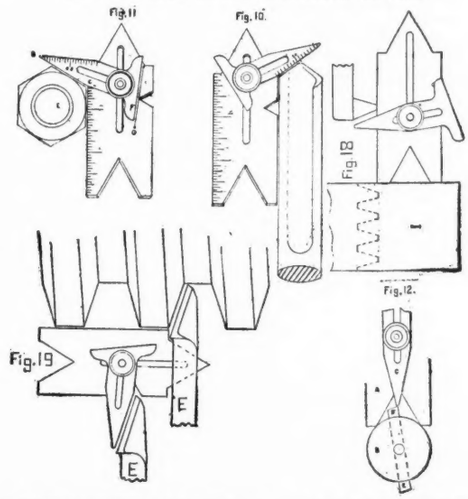
NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD. FOR FURTHER PARTICULARS, ADDRESS THIS OFFICE.

A correspondent would like to hear from manufacturers of automatic cock grinding machinery.

Another firm wishes to buy a machine for rolling paper tubes from 7/8 to 1 1/8 inches in diameter.

* * *

WYKE'S NO. 2 IMPROVED UNIVERSAL SCREW-CUTTING CENTER, DEPTH, ANGLE AND TWIST-DRILL GAUGE.



The No. 2 is an attractive and large size gauge, 4 inches long by 1 1/4 inches wide and 1/16 inch thick. It has a graduated scale 3 inches long on each side of the main gauge, and one on the auxiliary gauge 1 1/4 inches long. It can be used to gauge the largest as well as the smallest centers and twist-drills, also for the largest kind of screw-cutting; and especially for screws that are too large to be cut by tools filling the space of the thread, but which are cut by square and side tools which must be set to the exact angle required to form the thread. The graduated scale is useful to measure screw pitches, etc.; for the angles of small bevel gears, bevel collars, making angular templets, angular tools for lathe or planer, and all similar short work; it is the handiest tool in use.

As a Twist-Drill Gauge it is the simplest and most practical tool in the market; by its use a tool can be ground by hand as accurately as by machine. Fig. 10 shows the tools as set for gauging twist-drills, which operation is as follows: Throw the tongue of the auxiliary gauge back and set at the angle of one of the lips of the drill. Notice which line of the graduation coincides with the point of the lip, then bring round the other lip to the gauge, when the difference (if any) will be seen at once. This is an important feature where there is no drill grinding machine in the shop, and in any case it is well to test drills before using, whether they have been ground by machine or not. N. B.—The graduated scale on the auxiliary gauge is intended for use when gauging drills only.

To Set the Gauge to 120 Degrees. Set the edge F, of the auxiliary gauge Fig, 11, exactly parallel to line G. The angle thus formed by the gauge at A, B, C, will be 120 degrees, or two sides of a hexagon. E represents a hexagon nut.

Setting Cutters in Boring Bars. In cases where cutters are not notched to fit the bars, it is difficult to set them correctly; but by using the No. 2 gauge as above shown in Fig. 12, it becomes a very simple operation. Set the main gauge A, on the bar B (Fig. 12), then set the tongue of the auxiliary gauge C, to one edge of the cutter D, then apply the gauge to the other edge of the cutter E, and the difference will be seen and can be adjusted accordingly. When making the cutters the gauge can be used when backing them off equally.

Fig. 18 shows method of setting inside thread tools, by the auxiliary gauge; I, shows a section of nut.

Fig. 19 shows method of setting side tools, to cut large worms or screws E, E, hows the tools as set by the gauge and in position to cut.

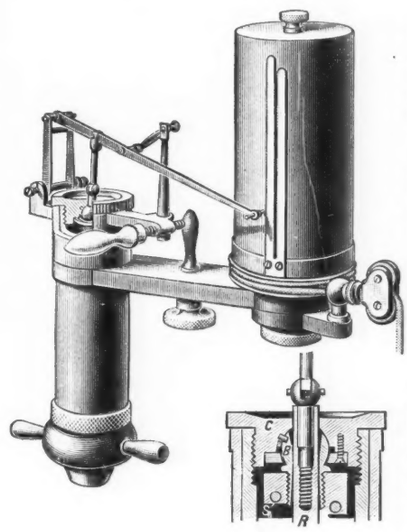
For further information address J. Wyke & Sons, East Boston, Mass.—ADV.

* * *

THE ROBERTSON-THOMPSON INDICATOR.

WITH BALDWIN'S DEVICE.

Probably in no branch of steam engineering has more ingenuity been expended, than in the attainment of the nearest approach to absolute accuracy in the use of the steam engine indicator. The fraternity is not content with an APPROXIMATION—perfect accuracy is demanded.



For years every detail of this instrument has been under the closest scrutiny, in order that its accuracy would remain unimpaired under the severest conditions of use.

The worst enemy to correct practice is friction in the moving parts, and no instrument is considered worthy of confidence, unless the piston and parallel motion will drop freely throughout the limits of their movements, without the slightest suspicion of a "catch;" as this must be accomplished without appreciable lost motion in any joint, its attainment is only possible by the most perfect design, and workmanship of the very highest order.

To be assured that a slight friction will not be contributed by the final adjustment of the spring, it has been usual to provide some form of a "universal" or "ball and socket" joint for its attachment to the piston.

Owing to the fact that this, as well as every other part subject to movement, must be constructed as light as possible, this ball joint has been made much smaller than considerations and lubrication, and freedom from wear under the excessive pressure would indicate.

To overcome this difficulty, the arrangement shown in the accompanying engraving has been devised. Briefly speaking, it consists in transferring the ball and socket joint from the piston to the cylinder head, where it has no movement, so that it can be made with a wearing surface probably fifty times greater than has been usual. As it requires no attention in changing springs, there are no adjusting screws which, sooner or later, will work loose while in operation, and vitiate the diagram.

The fact that it can be lubricated at frequent intervals, while in use, is also worthy of consideration.

This device involves all the principles and has all the advantages claimed for the previous construction. It can be applied to any standard indicator at present on the market. Address Hine & Robertson, 75 Cortlandt street, New York. —ADV.

TO EARN MORE, LEARN MORE

The Correspondence School of Technology, Cleveland, Ohio.

MECHANICAL, ELECTRICAL, STEAM AND OTHER BRANCHES OF ENGINEERING, TAUGHT BY MAIL. EACH COURSE INCLUDES DRAWING, PHYSICS, MATHEMATICS, ETC.

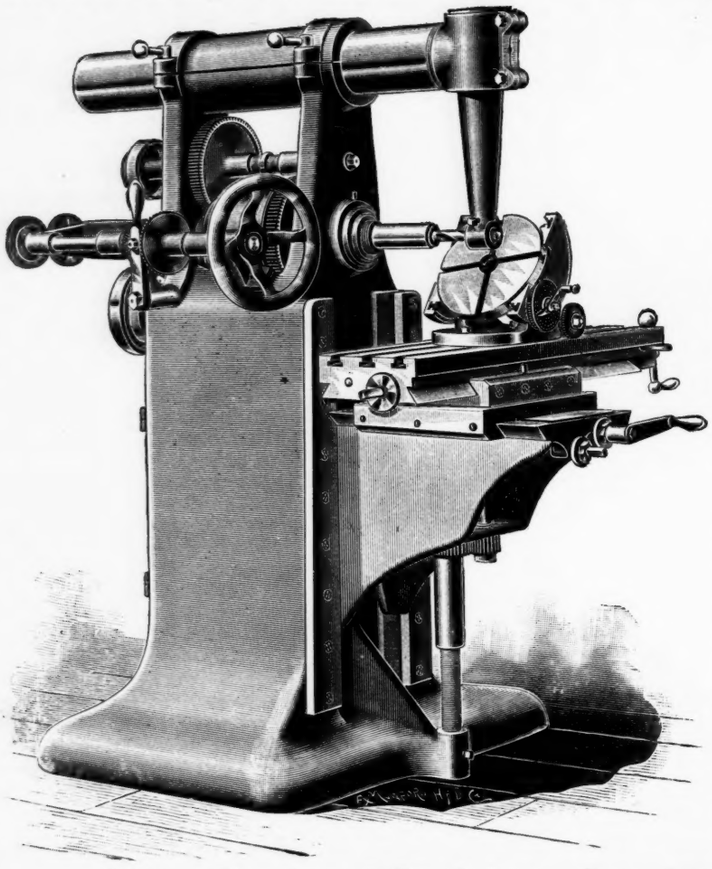
E. P. ROBERTS, M. E., President. **Send for Catalogue.** J. C. GALLUP, Secretary.

Till Jan'y First only.

No more of these **TWO INCH STEEL RULES** with ends **HARDENED** for TEN CENTS (stamps or silver) after Jan. 1, '96. If you want one, send NOW. Only one rule to each address.

STANDARD TOOL CO.,
MANUFACTURERS OF
MECHANICS' FINE TOOLS,
Athol, Mass.

Combination Universal Boring and Universal Milling Machine.



This machine is of a new construction, entirely different from anything made and original.

It's construction is that of a strong Universal Milling Machine with a good many new features in the minor parts. The principle feature of the tool is that it has double spindles, the main spindle, and another a telescoping spindle, lying inside of the main spindle and splined to it. This telescoping spindle is operated automatically or by hand, by a specially constructed feed screw and nut. The arm and pendant are arranged so that besides being a support for an arbor in axial milling it becomes a support for boring bars, by which the bar can be held at two points the length of the cut to be taken, making a perfect drill jig when drilling from the smallest hole to the capacity of the machine. As all the moving parts of the tool are graduated to .001 inches, it will be seen that work can be strapped to the platen, and with only the one setting it can be face milled, axially milled, butt milled, bored, drilled, reamed, etc., etc., at distances or angles laid out by the machine itself.

The Franklin Institute awarded the makers the John Scott medal, and in their award say "when used as a boring machine or as a milling machine, the functions of neither are impaired by the combination, and the limit of capacity seems to be the strength of the cutting tools." On all the machines of any size this company give special attention to the main spindle of the tools, which are of steel, hardened and ground with a liberal taper, by which they are able to use any of their machines for face milling with a certainty that the main spindle cannot get out of alignment.

The large range of work which can be done on these machines and the ease with which the work can be placed for operations seems to place it first as a tool room machine and a general shop tool.

The States Machine Co., Hartford, Conn., U. S. A.

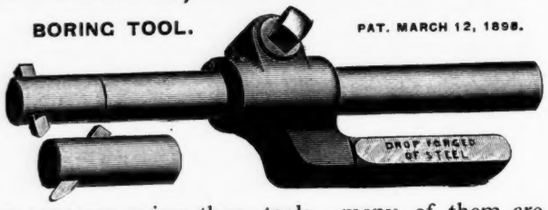
Armstrong Patent TOOL HOLDERS
For Turning, Planing and Boring Metals.

SAVES
Forging,
Grinding,
Tempering.

LATHE AND PLANER TOOL.
PATENTED FEBRUARY 28TE, 1893.

OVER 50,000 NOW IN USE.

BORING TOOL. PAT. MARCH 12, 1895.



SAVES
Tool-Steel,
Time,
Annoyance.

Just a few of the well known concerns using these tools—many of them are using from 100 to 300 tools—

Fitchburg Machine Works,
Builder's Iron Foundry,
Brown & Sharpe Mfg. Co.,
Jeansville Iron Works,
Woonsocket Mach. & Press Co.,
De LaVergne Ref'g. Mach. Co.,
Lodge & Shipley Mach. Tool Co.,
The Crane Co.,
Walburn-Swanson Co.,
Niles Tool Works,
Bickford Drill & Tool Co.,
Moran Bros. Co.,
Pelton Water Wheel Co.,
Warner & Swasey,
Frick Co.,
F. E. Reed Co.,
Standard Tool Co.,
Kempsmith Mach. Tool Co.,
Lane & Bodley Co.,
Cincinnati Milling Machine Co.,
Morse Twist Drill & Mach. Co.,
Chicago Screw Co.,
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The G. A. Gray Co.,
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Cambria Iron Co.,
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Illinois Steel Co.,
Bass Fdy. & Mach. Co.,
Illinois Central R. R. Co.,
Wisconsin Central R. R. Co.,
A. L. Ide Engine Co.,
The Long & Allstatter Co.,
Landis Bros.,
Geo. B. Grant,
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Wiley & Russell Mfg. Co.,
Chandler & Taylor Co.,
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Tinius Olsen & Co.,
Pawtucket Mfg. Co.,
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Sterling Cycle Works,
Curtis & Co. Mfg. Co.,
Fishkill Landing Mach. Co.,
The Purdue University,
The Laidlaw-Dunn-Gordon Co.,
Atchison, Topeka & Santa Fe R. R. Co.,
J. A. Fay & Egan Co.,
The Garvin Machine Co.,
Globe Iron Works Co.,
Remington Machine Co.,
Cyrus Currier & Son,
J. S. Mundy,
The Billings & Spencer Co.,
L. Wright Machine Works,
Edwin Harrington's Sons Co.,
P. P. Mast & Co.,
Sulzer-Vogt Machine Co.,
The Dayton Gas Eng. & Mfg. Co.,
Advance Thresher Co.,
The Adams Bros. Co.,
The Goss Printing Press Co.,
Medart Patent Pulley Co.,
The Horne & Danz Co.,
The Pratt & Whitney Co.,
Butterfield & Co.,
W. P. Callahan & Co.,
Manchester Locomotive Works
and hundreds of others.

Send to your dealer for one of these tools and give it a trial. Manufactured only by

ARMSTRONG BROS. TOOL CO., 82 EDGEWOOD AVE., CHICAGO, ILL.

CHAS. CHURCHILL & Co., Limited, London, England, Agents for Great Britain